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# Lynn and Inner Dowsing Hydrographic Monitoring Survey

**centrica**  
**energy**

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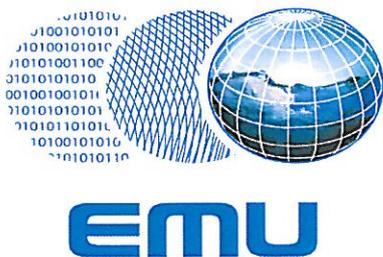
Report No: 09/□1/02/1495/0925

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Emu contact: Peter Major

**AUDIT INFORMATION**

| <b>Title: Lynn and Inner Dowsing Hydrographic Monitoring Survey</b> |   |                   |           |
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| Job No  | : J/1/02/1495                                       |                   |           |
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| Project Manager   | : James Cook  |                   |           |
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| Data Processors   | : James Cook, Sam Drawbridge, Rob Arnold            |                   |           |
| Ecological Surveyors  | : Adrian Cherry, Paul English                       |                   |           |
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| Report authorised by  | Huw Powell  | <i>H. Powell</i>  | 14.12.09  |
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|            |   |  |
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## EXECUTIVE SUMMARY

Emu Ltd was commissioned by Centrica Renewable Energy Limited to undertake a post construction hydrographic monitoring survey of the Lynn and Inner Dowsing wind farm sites and export power cables to shore.

The purpose of the survey was to determine the bathymetry, seabed types and distribution of benthic habitats in the wind farm and associated surrounding areas. The relevant data were collected through a combination of swath bathymetry, sidescan sonar, multibeam acoustic backscatter data, drop down video and grab sample surveys.

The hydrographic survey was carried out using the vessel *FPV Morven* on a 24 hour operational basis between the 30<sup>th</sup> June and the 26<sup>th</sup> July 2009. Survey lines were run using a line plan which amounted to approximately 1542 line kilometres. The drop down video and grab survey was conducted between the 9<sup>th</sup> and the 12<sup>th</sup> of September 2009 using the survey vessel *Arie Dirk*.

The bathymetric data collected for this report were of very high quality. Bathymetric data were reduced to Chart Datum (CD) using post processed kinematic (PPK) GPS tidal heights recorded onboard the survey vessel. These data were cross-checked with observed tides retrieved from the British Oceanographic Data Centre (BODC). Depths ranged from approximately 4.0m to 16.5m below CD at Skegness.

The sidescan data collected were also of a high quality and full insonification of the seabed was obtained even though data collection was hindered by the acute shallowness of the site in some areas. The data were processed using manual laybacks and cross checked against the bathymetric survey data.

Multibeam acoustic backscatter data were collected with the Reson 8101 in addition to the collection of bathymetric data. Once collected, the data were processed using QTC MULTIVIEW software which uses multivariate statistical techniques to analyse the backscatter intensity. The data were then cross checked against the sidescan imagery and the bathymetric survey data.

Video footage was acquired at 38 predetermined sites to ground truth sidescan sonar and bathymetric data collected prior to the ecological survey. Grab samples were obtained from 10 predetermined grab sites, to ground truth acoustic sediment type descriptions and from a further 8 sites, to assess *Sabellaria spinulosa* and *Ampelisca diadema* aggregations.

*Sabellaria spinulosa* was identified in the survey area in a range of forms including tubes, crusts, clumps and potential low-lying reef. Dense seed mussel beds, *Ampelisca diadema* reef and old mussel patches were also found within the survey area.

The ground truth data provided by the video imagery and grabs, allowed the sidescan interpretation to be modified to show the likely extent of the *Sabellaria* reefs, seed mussel beds and old mussel patches.

Results showed that the potential low lying *Sabellaria* reef was located in four main areas within the Lynn and Inner Dowsing wind farms. Dense seed mussel beds were found at three sites one of which was in conjunction with *Sabellaria* reef.

Data obtained from this survey were consistent with previous data collected at this site and within survey specification. As a result, all contractual requirements were deemed to have been met.

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## 1.0 INTRODUCTION AND OBJECTIVES

### 1.1 Background to the study

Emu Ltd was commissioned by Centrica Renewable Energy Ltd to undertake hydrographic surveys of the Lynn and Inner Dowsing Wind Farms and their export power cables to shore, with the aim of mapping bathymetry, agglomerations of the annelid worm *Sabellaria spinulosa* and other surface features such as wrecks, sand waves and mussel beds. Ground truthing of the acoustic data by drop-down video camera and grab sampling was also required to map sediment types and the extent of *Sabellaria spinulosa* reefs and shellfish beds. The information was required to allow monitoring of any change in seabed morphology and the size and distribution of *Sabellaria spinulosa* agglomerations across the wind farms, since their construction. Survey and assessment methods included the following;

- A swath bathymetry survey along the cable routes, main area and sand wave area on the Lynn and Inner Dowsing sites providing full coverage in order to define water depths and seabed gradients. Data were required to meet IHO Order 1 specification. Additional small areas also required surveying and encompassed the Docking Shoal and Race Bank Metmasts and the proposed Lincs offshore substation.
- A high resolution sidescan sonar survey providing full coverage of the area in order to determine variations in seabed type, locate any debris on the seabed and provide information on distribution of benthic habitats.
- Multibeam Acoustic Backscatter Data to provide data on variations of seabed types and habitats. Sidescan sonar data were to be used to supplement and verify this data.
- A drop down video and grab sample survey to ground truth the acoustic data and classify and map potential features of interest such as *Sabellaria spinulosa* aggregations and mussel beds.

In addition to the general description of *Sabellaria* reef distribution across the study area the scope of work required that the report specifically comment on the distribution of *Sabellaria* reefs and/or agglomerations along the inter-array cable runs on the Lynn Wind Farm (marked in green on Figure 1.4.2).

### 1.2 Hydrographic Survey

Bathymetric data were reduced to Chart Datum (CD) using post processed kinematic (PPK) GPS tidal heights recorded on board the survey vessel. These data were cross-checked with observed tides retrieved from the British Oceanographic Data Centre (BODC). All sources of tidal data were reduced to CD at Skegness (3.75m below Ordnance Datum at Newlyn).

Geophysical and hydrographic data were collected at 25m to 40m line spacings in order to fulfil IHO order 1 specifications for swath bathymetry. This required lines spacing to be either three times average water depth or 25m, whichever was greater. This line spacing also allowed for well over 200% insonification of the seabed with the sidescan footprint set to a range of 50m for each channel either side of the track.

All lines were run with all survey sensors. This included the multibeam echosounder simultaneously collecting swath bathymetry and multibeam acoustic backscatter data and the sidescan sonar. In most instances adjacent lines were run in opposite directions.

Survey lines were run according to a line plan which amounted to approximately 1542 line kilometres. The following line numbering convention was used:

**Table 1.2.1 Line Plan**

| Area                | Start Line | End Line | Line Spacing | Line length |
|---------------------|------------|----------|--------------|-------------|
| Cable route 1       | CR1 01     | CR1 19   | 25m          | ~4550m      |
| Cable route 2       | CR2 20     | CR2 28   | 25m          | ~3800m      |
| Cable route 3       | CR3 29     | CR3 43   | 25m          | ~3750m      |
| Cable route 4       | CR4 44     | CR4 52   | 25m          | ~4120m      |
| W of main area      | MA 001     | MA 070   | 25m          | ~10860m     |
| Centre of main area | MA 071     | MA 122   | 30m          | ~10860m     |
| SE of main area     | MA 123     | MA 168   | 40m          | ~3500m      |
| Sand wave area      | SW 01      | SW 17    | 50m          | ~725m       |

In addition, bathymetry coverage could be observed real-time in the QINSy navigation software. Any areas that may not have had adequate coverage were infilled. Refer to Figure 1.4.1 for an overview of the main site and line plan.

### 1.3 Previous Studies at Lynn and Inner Dowsing Wind Farms

*Sabellaria spinulosa* aggregations have been found within the survey area previously, both during a baseline study undertaken by Envision Mapping Limited (Sotheran *et al.*, 2005) and a survey undertaken by the Eastern Sea Fisheries Joint Committee (ESFJC, 2008).

*Sabellaria spinulosa* (also known as the ‘Ross worm’), is a suspension feeding, epifaunal polychaete that builds rigid tubes from sand or shell fragments. Individuals can be found living alone or in small groups; however in favourable conditions colonies producing fused sand tubes can form crusts, clumps or in some cases extensive biogenic reefs which can cover several square kilometres (Hendrick & Foster-Smith, 2006).

In its reef form, *Sabellaria spinulosa* is listed as a biogenic reef under Annex I of the EC Habitats Directive (Council Directive EEC/92/43 on the Conservation of Natural Habitats and of Wild Fauna and Flora). In addition, *Sabellaria spinulosa* reef is also included on the UK list of Priority Habitats for conservation action under the UK Biodiversity Action Plan (Maddock, 2008).

The survey by ESFJC (2008) also found areas of seed blue mussel, *Mytilus edulis*, beds. The term ‘seed mussel’ is used mainly by the fishing industry and has no precise definition. These mussels may be up to 2-3cm depending on local growth rates and are harvested in order to ‘seed’ the commercial mussel beds (Prof Ray Seed, pers comm. 03/12/09). Seed beds are usually fairly transient structures, left untouched they are normally decimated by predators or wave action and survive only for a relatively short period of time.

Determining if a mussel bed can be classified as a reef and therefore afforded statutory protection is difficult, as the definition of a biogenic reef can itself be quite vague:

“Solid, massive structures which are created by accumulations of organisms, usually rising from the seabed, or at least clearly forming a substantial, discrete community or habitat which is very different from the surrounding seabed. The structure of the reef may be composed

almost entirely of the reef building organism and its tubes or shells, or it may to some degree be composed of sediments, stones and shells bound together by the organisms” (Holt *et al.*, 1998).

However, seed mussel beds would not normally be regarded as biogenic reefs which tend to be more permanent features (Prof Ray Seed, pers comm.; 03/12/09 & 07/12/09). As such, they would not ordinarily be afforded protection as an Annex 1 reef habitat under the Habitats Directive.

The study by Sotheran *et al.* (2005) also found areas dominated by the tube building amphipod, *Ampelisca*, within the survey area. Several studies in the US have looked at the occurrence of *Ampelisca* dense tube mats and their potential beneficial effects for associated fauna (Mackenzie *et al.*, 2006; Diaz, 2007). At present, there is no EU or UK statutory protection for *Ampelisca* communities.

#### **1.4 Scope of Work**

The scope of work was set out in Contract 300404 VO 005 and 006. These documents detailed the objectives and methodology to be employed during the survey. This included the location of the survey areas for the initial hydrographic and geophysical survey using acoustic methods and the subsequent location of the groundtruthing array. The main survey area and sand wave area, including the final survey lines are presented below in Figure 1.4.1. The video and grabbing survey array with the windfarm infrastructure are illustrated in Figure 1.4.2. Methodologies detailed in the contracts included the swath bathymetry survey, sidescan sonar survey, AGDS study and the grab and drop down video sampling.

In variation to this contract it was verbally agreed with the COMPANY REPRESENTATIVE to use QTC processing software to collect AGDS data using multibeam acoustic backscatter instead of the RoxAnn GD system.

As a requirement of contract VO 005, the COMPANY REPRESENTATIVE agreed to the number and location of the ground truthing sampling stations prior to commencement of sampling.

Processed and interpreted data were incorporated into a Geographic Information System (GIS) compatible with ESRI ArcGIS software, which included associated metadata.

Figure 1.4.1 Site Location Diagram and Line Plan

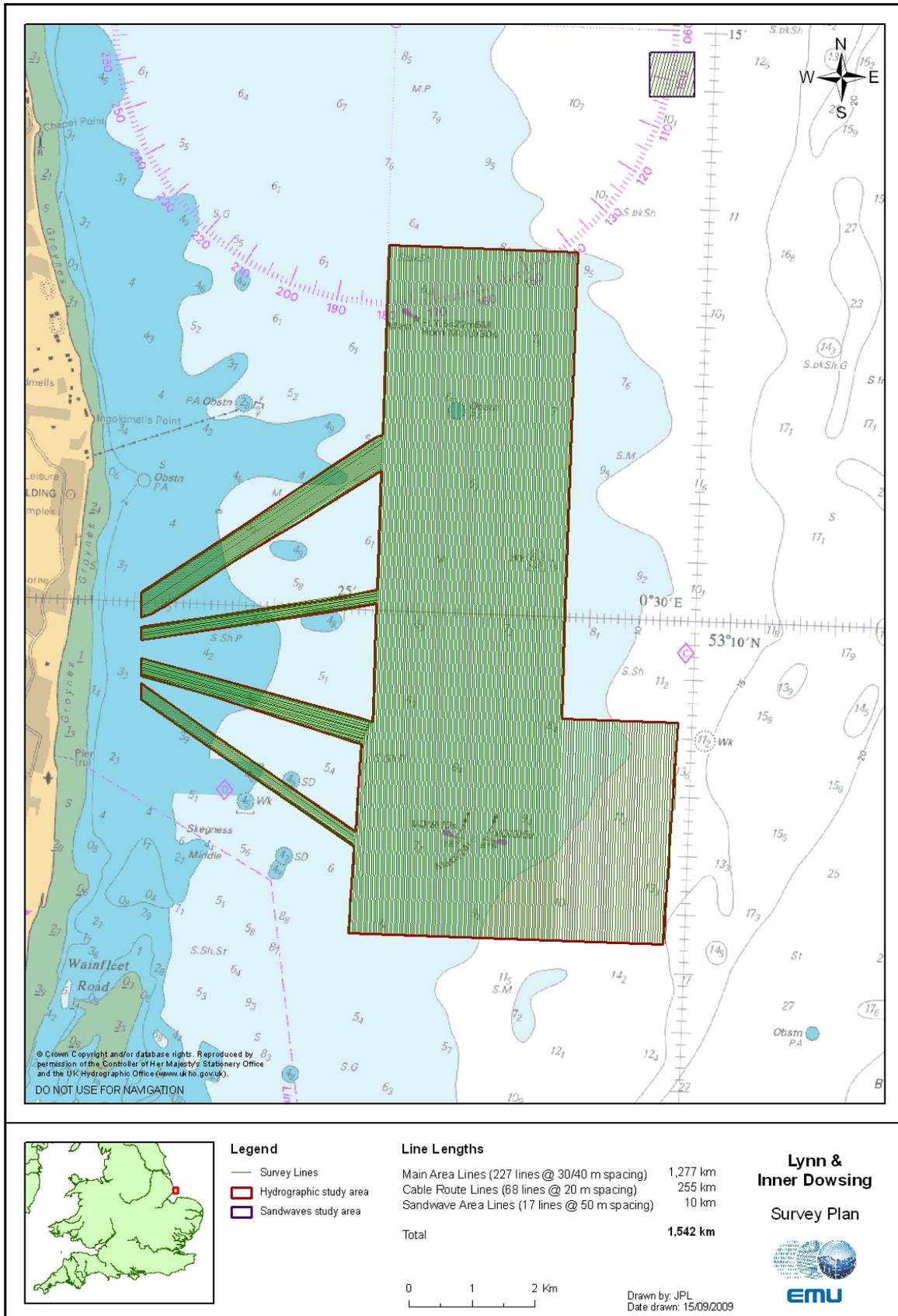
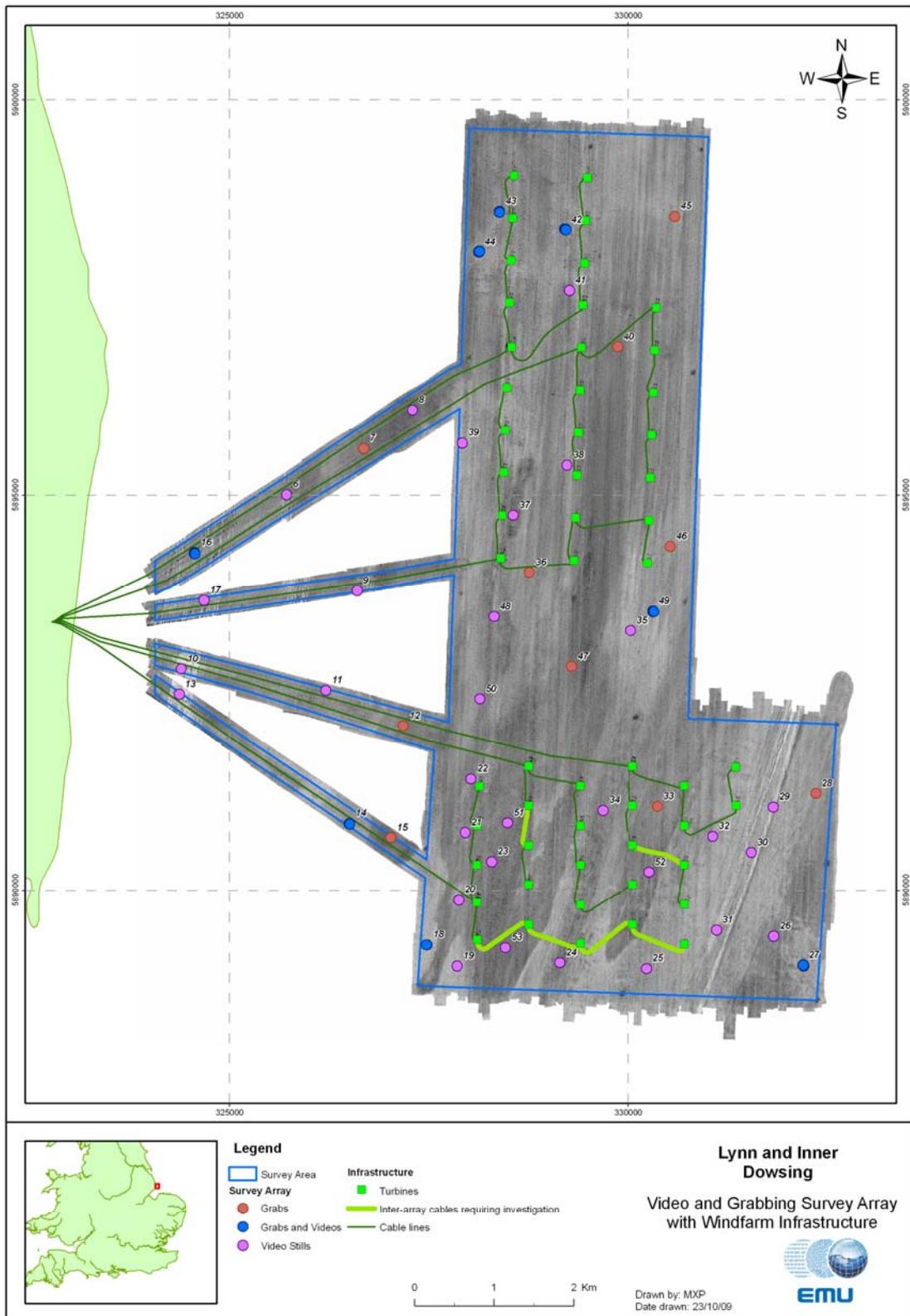


Figure 1.4.2 Video and Grabbing Survey Array within Lynn and Inner Dowsing OWF Area



## 1.5 Summary of Survey Events

The vessel *FPV Morven* was mobilised on the 29<sup>th</sup> June 2009 to begin the hydrographic survey on the 30<sup>th</sup> June 2009. All major hydrographic survey operations were completed by the 26<sup>th</sup> July 2009. There were two main periods of weather downtime, which were from the 7<sup>th</sup> to the 11<sup>th</sup> July and from the 18<sup>th</sup> to the 19<sup>th</sup> July. The hydrographic survey was carried out on a 24 hour operations basis simultaneously using the following sensors:

- A fully motion aided Reson 8101 multibeam echosounder
- A Klein 3000 sidescan sonar system
- An Applanix POS MV precision attitude and positioning system

The drop down video and grabbing surveys was conducted from the *Arie Dirk* between the 9<sup>th</sup> and the 12<sup>th</sup> September 2009. Daily progress logs can be found in Appendix B.

## 1.6 Key Personnel

**Table 1.6.1 Key Personnel**

| Personnel                    | Name  |
|------------------------------|---|
| Project Manager              | James Cook, Jo Weir                               |
| Senior Hydrographic Surveyor | Adam Cross  |
| Hydrographic Surveyors       | James Cook, Sam Drawbridge, Dave Stark, Al Rumson |
| Ecological Surveyors         | Adrian Cherry, Paul English                       |
| GIS                          | John Lonsdale, Matt Powell, Ian Rolls             |
| Reporting                    | James Cook, Peter Major, Erin Pettifer            |

## 2 METHODOLOGY

This section has been compiled to provide a brief description of the methods used to achieve the project objectives.

### 2.1 Horizontal Positioning

#### 2.1.1 Summary of Horizontal Positioning Systems

The following table summarises the details of the horizontal positioning systems used for the duration of the project.

**Table 2.1.1 Summary of Horizontal Positioning**

| HORIZONTAL POSITIONING   |                |   |          |
|--|----------------|---|----------|
| Requirement  |                | Application   |          |
| To provide navigation information to on board sensors with an accuracy of better than 3m (DGPS). |                | <b>Primary Positioning:</b><br>An Applanix POS MV precision attitude and positioning system was provided with EGNOS differential corrections via an interfaced Hemisphere Crescent R120 DGPS system.<br><b>Secondary Positioning:</b><br>The Hemisphere CrescentR120 DGPS system independently provided a DGPS solution using EGNOS differential corrections. |          |
| Data Collection  |                |   |          |
| <b>Survey Dates:</b>   |                | 30/06/2009 – 26/07/2009   |          |
| <b>Equipment Used:</b>   |                | Applanix POS MV<br>Hemisphere Crescent R120 DGPS<br>QINSy version 8 hydrographic navigation system  |          |
| <b>Vessel:</b>   |                | FPV Morven  |          |
| Navigation Settings  |                |   |          |
| Geodetic Parameters System Source (GPS)  |                | Projection Parameters   |          |
| Spheroid   | WGS 1984       | System  | UTM      |
| Semi-major axis  | 6378137.000000 | Zone  | 31 North |
| Semi-minor axis  | 6356752.314245 | Central Meridian  | 3° E     |
| Inverse Flattening   | 298.2572235630 | False Easting   | 500000   |
| Conversion factor to metres  | 1.0000000000   | Scale Factor  | 0.9996   |

#### 2.1.2 Methodology for the Horizontal Positioning Systems

DGPS positions were logged by the QINSy acquisition software at a minimum of five second intervals. Data quality was continually monitored and the system was set to reject position solutions which did not meet the accuracy requirements of this contract.

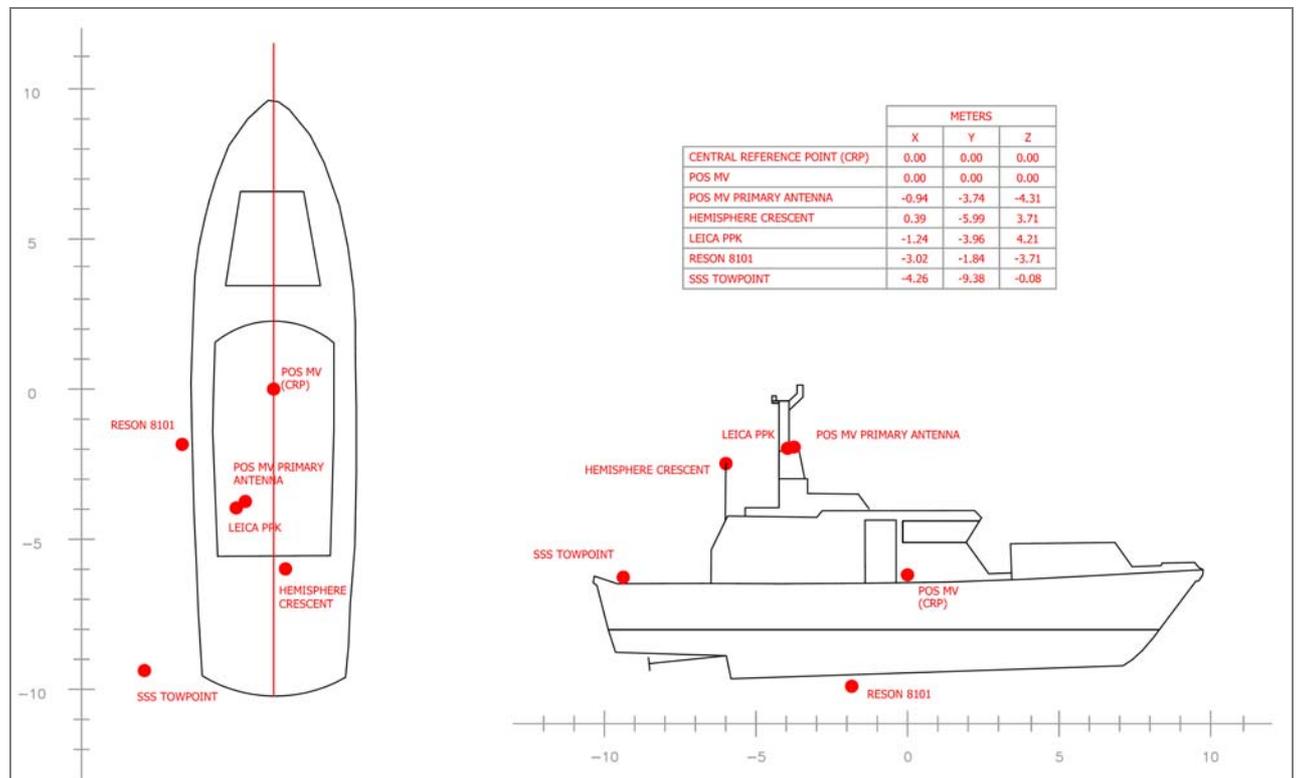
Prior to the commencement of the survey an RTK navigation check was conducted with the Leica 1200 unit at a known point maintained by the Environment Agency. The unit, having recorded satisfactory levels of accuracy was then taken back onboard the vessel and a real-time scatterplot comparison was conducted between the RTK and onboard DGPS units in the QINSy navigation software. Gross error navigation checks were also conducted when the vessel left harbour, the results of which are presented below in Table 2.1.2. All navigation checks showed the vessel positioning was operating within the manufacturers stated accuracies.

**Table 2.1.2 Gross Error Navigation Checks**

| Location               | Date     | Known Position |           | Vessel COG Position |           | Difference |      | Comments                          |
|------------------------|----------|----------------|-----------|---------------------|-----------|------------|------|-----------------------------------|
|                        |          | Easting        | Northing  | Easting             | Northing  | ΔE         | ΔN   |                                   |
| Southern Lock, Grimsby | 29/06/09 | 694248.4       | 5941062.5 | 694245.0            | 5941054.7 | -3.4       | -7.8 | Known point approx 6m stbd of COG |
| Southern Lock, Grimsby | 30/06/09 | 694248.4       | 5941062.5 | 694242.1            | 5941057.8 | -6.3       | -4.7 | Known point approx 7m stbd of COG |
| Southern Lock, Grimsby | 02/07/09 | 694248.4       | 5941062.5 | 694241.1            | 5941066.3 | -7.3       | +3.8 | Known point approx 7m stbd of COG |
| Southern Lock, Grimsby | 20/07/09 | 694248.4       | 5941062.5 | 694243.7            | 5941058.3 | -4.7       | -4.2 | Known point 7m stbd of COG        |

**2.1.3 Vessel Offsets**

Vessel offsets of the *FPV Morven* were based on a dimensional control survey performed by Oceanfix International Limited in June 2009. These measurements were confirmed before the survey commenced and entered into QINSy 8 software. The offsets are presented below:



**Figure 2.1.1 FPV Morven Vessel Offset Diagram.**

## 2.2 Swath Bathymetry Survey

### 2.2.1 Summary of Swath bathymetry system

The following table summarises the details of the swath bathymetry system used for the duration of the project.

**Table 2.2.1 Summary of Swath Bathymetry Survey**

| SWATH BATHYMETRY SURVEY   |   |
|---|---|
| Requirement   | Application   |
| To determine seabed depths throughout the site with full seabed coverage  | In order to measure the depths of all parts of the seabed, a swath bathymetry system built up a series of strips of bathymetric data to either side of the vessel as it moved forwards. Each strip or “swath” laid side-by-side enabled the entire seabed to be surveyed. |
| <b>Data Collection</b>  |   |
| <b>Survey Dates:</b>  | 30/06/2009 – 26/07/2009   |
| <b>Equipment Used:</b>  | Reson Seabat 8101 240kHz multibeam echosounder<br>POS MV motion reference unit<br>QINSy version 8 acquisition, navigation and processing software<br>Leica 1200 RTK GPS systems, configured to collect PPK data   |
| <b>Vessel:</b>  | <i>FPV Morven</i>   |
| <b>Outputs</b>  |   |
| <ul style="list-style-type: none"> <li>• Swath bathymetry colour shaded chart</li> <li>• Digital bathymetry data in XYZ format</li> </ul> |   |

### 2.2.2 Bathymetry Survey Methodology

The Reson Seabat 8101 swath bathymetry system emitted a series of 101 equally angled pulses of acoustic energy across the track of the vessel attaining full seabed coverage across the width of the swath. The time it took each beam to return to the system was accurately measured to derive the seabed depth at each point of insonification. The resulting swath soundings provided high resolution information on the bathymetry of the seabed across the whole area. Attitude and motion were measured by the POS MV motion reference unit giving heave, roll, pitch and heading data. This information was fed directly into the QINSy software for real-time corrections of the bathymetry. The swath system was calibrated prior to the survey with a standard patch test operation, which has been provided in Section 2.2.3. This revealed the fixed offsets in heading, pitch, and roll, and also any time delay in the position data.

A survey grid was constructed during survey operations to ensure that sufficient coverage was achieved. Initial data quality control checks were performed offshore using low resolution grid files.

Data were collected in lines, which were oriented from north to south with a line spacing that ranged from 40 metres (where depths were greatest) to 25 metres (where it was shallowest) and provided data that conformed to IHO Order 1 specifications. Gaps in the bathymetric dataset that existed after the survey grid had been run were covered by running additional infill lines where it was safe to do so.

Sound velocity profiles were taken every 12hrs during operations using a Valeport MiniSVP. These were loaded into the QINSy navigation software and applied online during data acquisition. Sound velocity profiles collected for the duration of the project have been presented in Appendix D.

The PPK tidal data were reduced to CD at Skegness (3.75 metres below Ordnance Datum at Newlyn). A composite graph displaying the BODC tide gauge and PPK tidal curves for the survey period has been presented as Appendix C.

Post-processing was performed at Emu Ltd's Durley office using QINSy software, which included the Qcloud 3D area based cleaning module. This allowed the removal of outliers with automatic and manual filtering techniques and the application of corrected tidal levels. The cleaned data were gridded using a 1 x 1 m bin size for inclusion in the GIS system where it was coloured shaded and plotted.

### 2.2.3. Patch Test Calibration

To calibrate for the attitude of the Reson 8101 multibeam echosounder a 'patch test' was undertaken. The mounting offsets of the multibeam head were determined by sailing a number of predefined lines:

- Roll: Two lines were surveyed over a flat area in opposite directions with the same speed
- Pitch: Two lines were surveyed over an area with slopes in opposite directions with the same speed
- Heading: Two lines were surveyed over an area with slopes. The lines need to overlap half a swath width in the same direction and at the same speed.

Latency is normally calibrated for during a patch test but was not necessary in this case as PPS data was applied directly to the multibeam system to provide an accurate time stamp.

The horizontal and vertical offsets of the multibeam echosounder head were accurately known from the dimensional control survey performed in June 2009 (detailed in section 2.1.3).

At the beginning of the patch test the pitch, roll and heading corrections in QINSy were set to zero. Upon the collection of the 'roll' data, these two lines were processed in the QINSy validator module and the derived correction for roll were applied to the QINSy software. The 'pitch' lines were then sailed and the data processed. The derived pitch corrections were applied to the QINSy software prior to the collection of the 'heading' data.

The calibration of the Reson 8101 system was conducted prior to the survey during a previous project on the 24<sup>th</sup> June 2009. No changes were made to the installed survey instrumentation between this date and the start of the survey operations on the Lynn and Inner Dowsing sites.

A further calibration was performed on 13<sup>th</sup> June 2009. This was performed en route to the site, over an area of flat seabed and an identified sandwave. Results from the patch test were in good agreement with the previous calibration. The results of the two patch tests are presented below in Table 2.2.2

**Table 2.2.2 Attitude corrections derived from patch test**

| Date         | Heading | Pitch | Roll |
|--------------|---------|-------|------|
| 24 June 2009 | -1.1    | -2.2  | 0.2  |
| 13 June 2009 | -1.1    | -2.2  | 0.4  |

## 2.3 Sidescan Survey

### 2.3.1 Summary of Sidescan System

The following table summarises the details of the sidescan sonar system used for the duration of the project.

**Table 2.3.1 Summary of Sidescan Survey**

| <b>SIDESCAN SURVEY</b>  |   |
|---|---|
| <b>Requirement</b>  | <b>Application</b>  |
| To collect sidescan data on the wind farm area and associated cable routes and sand wave area in order to determine sediment type and distribution.   | The sidescan sonar system emitted and recorded high frequency (500 kHz) and low frequency (100 kHz) pulses in order to ensure the best representation of the seafloor.        |
| <b>Data Collection</b>  |   |
| <b>Survey Dates:</b>  | 30/06/2009 – 26/07/2009   |
| <b>Equipment Used:</b>  | Klein 3000 dual frequency sidescan sonar system<br>Be-spoke cable winch with 300m of armoured cable<br>SonarPro data collection software<br>SonarWiz data processing software |
| <b>Vessel:</b>  | <i>FPV Morven</i>   |
| <b>Data Outputs</b>   |   |
| <ul style="list-style-type: none"> <li>• Trackplots</li> <li>• Sidescan Mosaic (Geotiff)</li> <li>• Raw XTF files</li> <li>• Interpretation of mosaic and comparison with previous survey data</li> </ul> |   |

### 2.3.2 Methodology of Sidescan Survey

The Klein3000 towfish was tested on-site before each deployment by performing the standard 'rub test'. This involved lightly rubbing the transducers by hand with the gain settings set to maximum. A dark line observed in the waterfall display confirmed the system circuitry was functioning correctly for both port and starboard transducers.

The sidescan fish was deployed and maintained in position using a HIAB crane and armoured cable winch. The tow point was positioned over the port side at the stern of the vessel. Layback values were ascertained by observing tape marks on the armoured cable. These tape marks were placed on the cable using a surveyors measuring tape at the start of the survey.

Survey lines were run at the same spacing as for the multibeam survey. The system was set to a range of 50m to ensure a minimum of 200% insonification of the seafloor. Both high and low frequencies were recorded. The height of the sidescan fish was set at 5-8m although this was reduced to 3-5m in shallow areas of the survey area.

Survey logs listing the data collection parameters were maintained for the duration of the survey.

Data were recorded on-site using the SonarPro recording software and processed at Emu Ltd's Durley offices using SonarWiz software.

## 2.4 Multibeam Acoustic Backscatter Survey

### 2.4.1. Summary of Multibeam Acoustic Backscatter Survey

The following table summarises the details of the multibeam acoustic backscatter survey employed for the duration of the project.

**Table 2.4.1 Summary of Multibeam Acoustic Backscatter Survey**

| <b>MULTIBEAM BACKSCATTER SURVEY</b>   |   |
|---|---|
| <b>Requirement</b>  | <b>Application</b>  |
| To collect multibeam acoustic backscatter data in order to determine alterations in seabed type and to attempt to detect <i>Sabellaria spinulosa</i> reefs within the area of the Lynn and Inner Dowsing wind farms and in the separate sandwave area | The Reson 8101 multibeam head measured and recorded the intensity of the acoustic backscatter whilst conducting the bathymetric survey. |
| <b>Data Collection</b>  |   |
| <b>Survey Dates:</b>  | 30/06/2009 – 26/07/2009   |
| <b>Equipment Used:</b>  | Reson 8101 multibeam system<br>QTC processing software  |
| <b>Vessel:</b>  | <i>FPV Morven</i>   |
| <b>Data Outputs</b>   |   |
| <ul style="list-style-type: none"> <li>• Raw data in digital format</li> <li>• Paper Chart</li> </ul>   |   |

### 2.4.2. Methodology of Multibeam Acoustic Backscatter Survey

Acoustic backscatter data were recorded from the Reson 8101 multibeam system alongside collection of bathymetry data. QINSy 8 software was set to log the snippet format output from the Reson 8101 system. This data was sent to Questor Tangent Corp where they used their proprietary software, QTC MULTIVIEW, to process the data. This uses multivariate statistical techniques to analyse the backscatter intensity in order to determine changes in seabed type and coverage. The resulting acoustic response then underwent cluster analysis to class the data. These classes represented distinct changes in backscatter and are termed ‘acoustic diversity’. The classes could then be classified from the ground truthing survey. Additional processing was performed by QTC CLAMS to output a GeoTIFF of the dataset. This GeoTIFF was plotted and is presented in drawing J.1.02.1495.05.

During the survey, data were checked regularly to ensure sufficient information was being recorded and survey logs listing the data collection parameters were maintained throughout the survey.

## 2.5 Drop Down Video and Grab Survey

### 2.5.1 Survey Design

Prior to survey works, the exact survey specification was supplied to Natural England and approved. The method for drop-down video surveying was based on JNCC Procedural Guideline No. 3-5 *Identifying biotopes using video recordings* (Holt, R. & Sandersen, B., 2001).

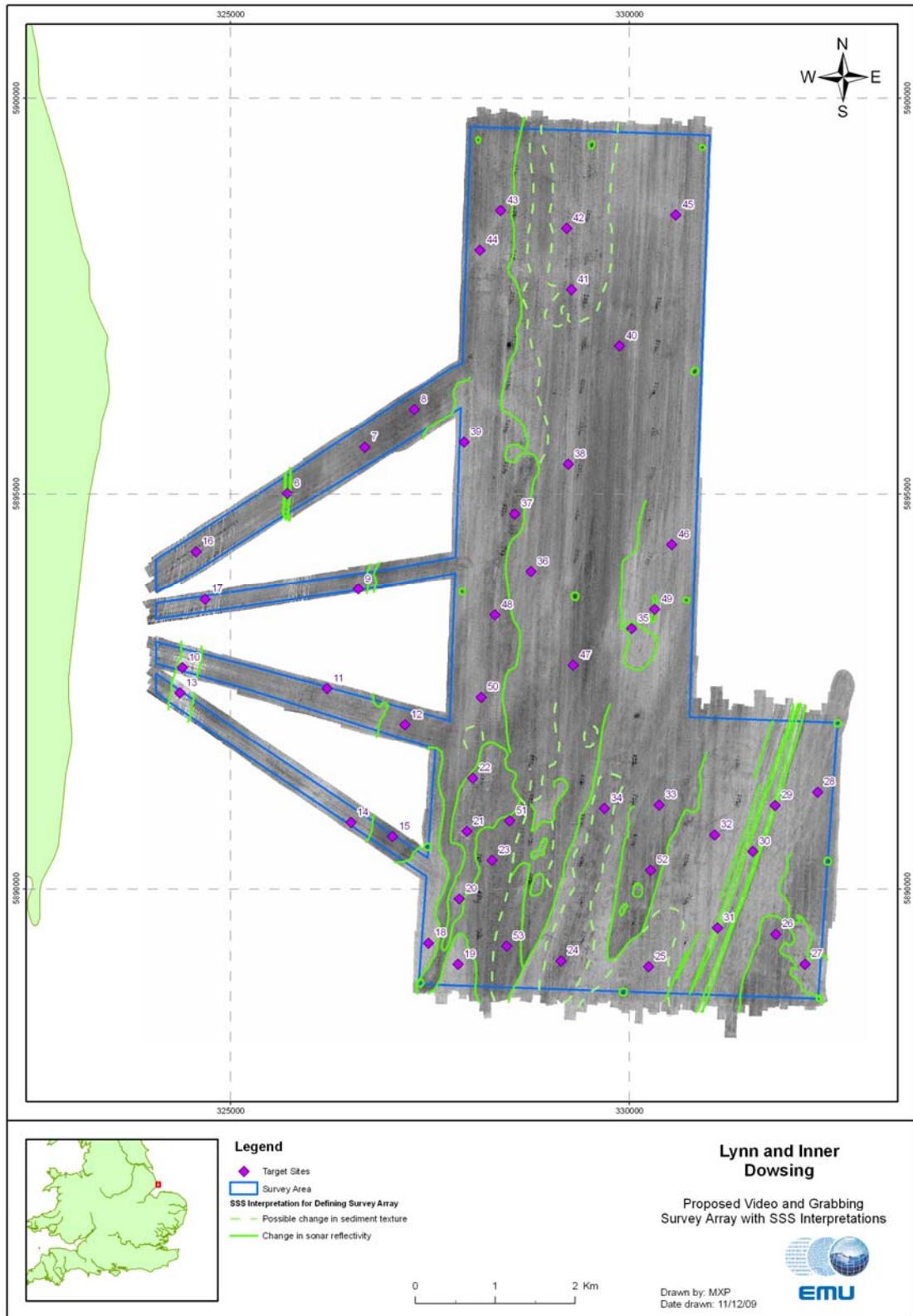
The drop down video and grab survey array was selected on the basis of the acoustic data collected. The initial sidescan sonar interpretation plots were utilised to identify regions considered worthy of further investigation. Areas presenting seabed features or changes in sediment composition, represented by differences in texture and or reflectivity in the sidescan sonar plots, were delineated and ground truth sites located within them. These areas were refined in the final sidescan sonar interpretation which was constructed following analysis of individual lines of data. This form of analysis provides much greater detail and definition of the boundaries, features and seabed types. Some of the areas within these refined boundaries were not covered by the ground truth array.

Table 2.5.1 contains a list of the sites selected for ground truthing and the specific feature observed in the sidescan sonar interpretation that prompted further investigation. Figure 2.5.1 illustrates the areas delineated on the initial sidescan interpretation and the location of the proposed ground truth sites.

**Table 2.5.1. Ground truth site selection**

| Ground truth site                     | Sidescan sonar interpretation & potential feature  |
|---------------------------------------|--|
| 6, 9, 10, 13, 16, 17, 29, 30, 31      | Areas with sandwaves & rough texture. Apparent superficial feature, possible <i>Sabellaria</i> associated with feature.  |
| 8                                     | High reflectivity with rough texture. Possible mussel bed.   |
| 11, 14                                | Rough texture with highly contrasting reflectivity. Possible <i>Sabellaria</i> .   |
| 18, 19                                | Low reflectivity – different to immediate surrounding areas. Possible <i>Sabellaria</i> .  |
| 20, 21, 22, 37, 48, 50                | Rough texture, lots of shadow – appears to be something with relief /on the sediment. Possible mussel bed/ <i>Sabellaria</i> .   |
| 23, 51, 53                            | Rough texture. Different sediment to surrounding area. Possible <i>Sabellaria</i> .  |
| 24, 34                                | High reflectivity with occasional patches of roughness. Different substrate from areas either side. Possible <i>Sabellaria</i> .   |
| 25                                    | Rough texture. Possible <i>Sabellaria</i> .  |
| 26, 27                                | Patchy reflectivity. Comparison between the darker, higher reflectivity area (Site 26) & the adjacent lighter, lower reflectivity area (Site 27). Possible <i>Sabellaria</i> . |
| 32, 52                                | Comparison between area of high reflectivity (Site 52) and an adjacent area of low reflectivity (Site 32) just outside the sandwave area. Possible <i>Sabellaria</i> .         |
| 35, 49                                | Low reflectivity area with patches of high reflectivity. Possible mussel bed/ <i>Sabellaria</i> .  |
| 41, 42, 43, 44                        | High reflectivity & rougher texture. Possible <i>Sabellaria</i> /mussel bed.   |
| 7, 12, 15, 28, 33, 36, 40, 45, 46, 47 | Predetermined sites selected to ground truth sediment types. Cover range of reflectivity's throughout the array.   |
| 38, 39                                | Low reflectivity with patches of high reflectivity. Possible mussel bed/ <i>Sabellaria</i> .   |

Figure 2.5.1 Proposed video and grabbing survey array with initial SSS interpretations



From the hydrographic survey interpretation 38 sites were identified to be ground truthed with the drop down video system and/or the mini-Hamon grab. An additional 10 sites were selected to ground truth sediment classifications from acoustic methods with the mini-Hamon grab. Included within these 48 sites were 5 stations (24, 25, 51, 52 and 53) that were also selected to illustrate the distribution of *Sabellaria* reefs and/or agglomerations along the inter-array cable runs.

#### ***Selection of the ground truth procedure for Sabellaria spinulosa***

Following earlier discussions with Natural England, a survey process was developed at Emu Ltd to enable *Sabellaria spinulosa* reef assessment to be undertaken where physical constraints exist, particularly with respect to water visibility. The objective when surveying potential Annex 1 habitats is to allow assessment of the status of any suspected reef areas (initially defined by acoustic methods) without causing any unnecessary damage.

The following are the key features that are required to determine the presence of *Sabellaria spinulosa* reef:

- Height (2cm or more high)
- Extent
- Patchiness

Based on the acoustic data, particularly sidescan sonar, the likelihood of correctly identifying *Sabellaria spinulosa* reef can occur in the range from minimum to maximum probability due to differences in data quality and difficulty in the interpretation of data. Alternative seabed types also occur, including clumps, crusts, tubes or no *Sabellaria spinulosa*. The following scenarios are possible where a good degree of certainty exists, with the subsequent table (Table 2.5.2) summarising the options where the ability of identifying the feature is less certain.

#### **a) Potential Reef areas**

In areas where maximum probability of *Sabellaria spinulosa* reef has been identified then the stages of assessment should comprise of an initial dropdown video assessment, using a low visibility system (a video system housed within a box filled with fresh water). Should this prove sufficient to determine that the *Sabellaria spinulosa* is continuous (i.e. not clumped) and of significant height, this data will be used in conjunction with the acoustic data to describe the extent and patchiness of the reef.

Following further discussions with Natural England, it is proposed that a 0.1m<sup>2</sup> Mini-Hamon grab be deployed if the video data provides an image of the seabed which appears to comprise of *Sabellaria* reef, but which does not assist with determination of height or patchiness. Using a Mini-Hamon grab increases the likelihood of obtaining a sample and this should be able to confirm the height of the reef feature up to a maximum of 15cm. Should the video data fail to collect any valid data then it is proposed that the Mini-Hamon grab is immediately deployed.

If the video data is sufficient for an assessment of the height and patchiness of the reef, it is proposed that a limited number of grab samples are collected, in order to enable an assessment of the quality of the reef to be made in terms of elevation of reef, percentage coverage within grab bite, degree of consolidation of reef and any conspicuous crevice fauna associated with the reef.

**b) Clumps**

Where clumps are anticipated based on the acoustic data, it is proposed that a greater number of drops (5) will be required over a wider area. If the *Sabellaria* can be identified then height and patchiness may be acquired if the image quality is good. The Mini-Hamon grab will be deployed only to confirm lack of *Sabellaria* as probability of sampling clumps will be low.

**c) Crust**

Due to the low lying nature of this crust form of *Sabellaria*, this may not be readily identified using sidescan sonar. The approach used to identify crusts will be to deploy the low visibility clear box system, using dropdown video techniques. The Mini-Hamon grab will be deployed in all instances to confirm that the *Sabellaria* is only a crust.

**d) No *Sabellaria***

Groundtruth with mini-Hamon grab only.

**Table 2.5.2 Proposed *Sabellaria* ground-truthing procedure.**

| Seabed type                 | Maximum probability   | Minimum probability   |
|-----------------------------|---|---|
| <b>Potential Reef</b>       | Small number low visibility video - drop down<br><br>If poor image or unable to obtain idea of height of reef then mini-Hamon grab  | Small number low visibility video - drop down<br><br>If poor image or unable to obtain idea of height of reef then mini-Hamon grab  |
| <b>Clumps</b>               | A number low visibility video - drop down<br><br>Only mini-Hamon grab if no good image or seabed appears to be no <i>Sabellaria</i> | A number low visibility video - drop down<br><br>Only mini-Hamon grab if no good image or seabed appears to be no <i>Sabellaria</i> |
| <b>Crust</b>                | Low visibility video - drop down<br>Immediate mini-Hamon grab sampling.   | Mini-Hamon only   |
| <b>No <i>Sabellaria</i></b> | Mini-Hamon grab only  | Mini-Hamon grab only  |

It should be noted that the procedure described above, was a proposed procedure. When on site, the longer video footage duration (see section 2.5.2) and the low visibility system utilised, generally provided clear images of the seabed type and grabs were only taken:

- At the 10 predetermined sites utilised to groundtruth sediment types interpreted from acoustic data.
- If the video footage was not clear and the surveyor was unable to interpret it.
- If the surveyor thought *Sabellaria* crust was present.

However, difficulties arose with identifying *Sabellaria* crust in the field. In some of the video footage it was hard to distinguish due to its low-lying nature, the speed of the current and the silt content in the water column. Post survey processing, utilising enhanced, clearer static

images, revealed *Sabellaria* crust at some sites which had not been identified in the field and therefore not grabbed.

### 2.5.2 Drop Down Video Survey

The methods for drop down remote video associated with the collection of ecological information and habitat recording followed, where applicable, those laid out in the JNCC UK Marine Special Area of Conservation (SAC) Project Handbook for the biological monitoring of marine SACs (Hiscock, 1998). More detailed interpretation of the video imagery was later undertaken by Emu Ltd. The drop down video equipment specifications are outlined in Table 2.5.3.

A drop down sub-sea video was deployed at 38 pre-determined sample locations. This technique involved the video equipment undergoing a controlled vertical drop to the seabed at each location. This technique has an advantage over towed video methods as it prevents possible damage to sensitive ecological features on the seabed. Survey logs listing the data collection parameters were maintained throughout the survey.

Positions for the video survey were logged at the beginning and the end of each drop and overlaid on the video footage to ensure accurate geo-referencing. The use of the positioning system, including navigation checks were carried out in accordance with Emu Method Statement EMU05.

**Table 2.5.3 Summary of Drop Down Video Specifications**

| Drop Down Video Specifications  |  |
|---|--|
|  | <ul style="list-style-type: none"> <li>• Kongsberg OE14-208 new generation digital stills colour camera. Stills images are framed using real time video.</li> <li>• ELViS (Extreme Low Visibility System) – video camera was housed within a low visibility clear water box system due to potentially poor underwater visibility in the area. This system permits seabed footage to be collected in turbid waters as it provides a clear column of water between the camera lens and the seabed. The base of the box was positioned approximately 3.5cm above the seabed.</li> <li>• Subsea camera telemetry cable system (200m)</li> <li>• Bespoke topside control unit (comprising a 400GB Hard Disk Drive (HDD) incorporating a DVD recorder for use as the primary video recording system, 15” LCD monitor, with GPS Overlay using a Hemisphere Crescent V100 series DGPS system)</li> <li>• Mini-DV player and full screen colour monitor for simultaneous backup.</li> <li>• Horizontal positioning was provided using a Differential Global Positioning System accurate to ±5m in conjunction with the navigation software package Trimble HYDROPro.</li> </ul> |
| <p><b>Deployment of drop down video system housed within ELViS</b></p>              |  |
|  |  |
| <p><b>Example stills image of seed mussel and <i>Sabellaria</i> reef.</b></p>       |  |

At each station approximately 10 minutes of digital video footage of the seabed was collected rather than the anticipated 3 minutes. During the deployment, the video signal was monitored onboard the vessel to assess the quality of the footage and adjustments were made if appropriate. Due to the level of suspended sediment observed, a longer duration (10 mins) for filming was decided upon in the field to ensure sufficient quality footage was obtained so that subsequent assessments of sediment type and feature condition would be made with the greatest degree of confidence.

### 2.5.3 Mini-Hamon Grab Survey

The grab sampling was performed according to Emu method statements (Emu Met/05 for infaunal and epifaunal sampling; Emu Met/06 for sediment sampling and processing), each of which comprises a component of our QA procedures. The mini-Hamon grab equipment specifications are outlined in Table 2.5.4

Grab sampling was undertaken at 10 pre-determined stations in order to ground-truth sediment types. More detailed analysis of the sediment composition of these 10 grab samples was later undertaken at Emu Ltd by the Geosurvey department to assist their acoustic data interpretation. An additional 8 grabs were taken at sites where *Sabellaria* or *Ampelisca* crust were present to further assess these features.

Not all sites containing *Sabellaria* crust were grabbed as its low lying nature and the high degree of suspended sediment hindered its detection in the video footage being monitored in the field. It was only on closer examination of the enhanced, clearer stills images following survey work that a number of *Sabellaria* aggregations were identified. Enough good quality footage and stills images were obtained to classify areas.

At each station selected for grab sampling, the grab sampler was deployed to the seabed and a position recorded. Upon recovery of the grab sample, the sediment sample was viewed to record any surface features such as tubes or burrows. The sample was then emptied into a hopper, and a summary description of the sediment composition and any conspicuous species noted.

**Table 2.5.4 Summary of Grab Sampling Specifications**

| Grab Sampling Equipment Specifications  |   |
|---|---|
|  | <ul style="list-style-type: none"> <li>• 0.1m<sup>2</sup> mini-Hamon grab</li> <li>• 1mm sieves</li> <li>• Nikon Coolpix 7900 digital camera and housing for deck photography</li> <li>• Differential GPS accurate to ±5m.</li> </ul> |
| <p><b>Close up of Mini-Hamon Grab Sampler</b></p>                                   |   |

If *Sabellaria* was found within the sample, the height of the tubes was recorded together with an estimation of percentage live and percentage dead.

Two grab samples containing potential *Sabellaria* reef and dense *Ampelisca diadema* were returned to Emu's NMBAQC accredited laboratories to measure the height of *Sabellaria* tubes and to identify other species components of the associated communities.

All taxonomic analyses followed in-house method EMUMET07 "In house quality control methods for the processing, identification and recording of marine macro-invertebrates". The laboratory team are long-term participants in the National Marine Biological Association Quality Control Scheme (NMBAQC) and have consistently achieved high scores in terms of compliance (>95%).

## 2.6 Video and Stills Data Analysis

### *Interpretation of Sabellaria Aggregations*

#### Stage 1 – Sediment description and *Sabellaria* form present

Video footage from each site was reviewed and checked against the *in-situ* video records. The following information was reviewed during the analysis of video:

1. Substrate type
2. Presence of *Sabellaria spinulosa* was classified into the following categories where possible:
  - Absent
  - Moribund loose tubes
  - Crusts
  - Clumps (nodules of reef <10cm in diameter)
  - Potential Reef

#### Stage 2 – *Sabellaria* characteristics

Hendrick & Foster-Smith (2006) described a multi-criteria scoring system which can be used to give an overview of various characteristics considered important to the 'reefiness' of *Sabellaria spinulosa* aggregations.

It has been suggested (Hendrick & Foster-Smith, 2006) that each of the characteristics can be scored as Low, Medium or High, and be weighted according to the perceived importance of that characteristic. Table 2.6.1 summarises the characteristics that it is suggested, can be determined by video survey.

**Table 2.6.1 Summary of *Sabellaria* Characteristics based on Hendrick & Foster-Smith (2006).**

| Characteristic       | Measurement via video footage  |
|----------------------|--|
| <b>Elevation</b>     | The measurements can be estimated from video imagery. Alternatively it is possible to get an indication of the reef elevation from remote sensing techniques such as high frequency sidescan sonar or swath bathymetry (as obtained by the acoustic surveys prior to this video survey).   |
| <b>Patchiness</b>    | A rough indication of the patchiness of the reef can most easily be estimated from videography.  |
| <b>Consolidation</b> | As with elevation, an indication of the degree of sediment consolidation can be derived from vertical photography and video footage.   |
| <b>Density</b>       | The characteristics of biogenic reefs are all linked to the density of the aggregation. For instance it has been suggested, that the growth morphology of <i>Sabellaria spinulosa</i> maybe influenced by density, such that an upright growth form is a reflection of competition for space (Schwartz, 1932; Schafer, 1972). A rough estimate of density can be derived from videography. |

Whilst an overall score of these characteristics is an oversimplification, the approach attempts to encourage a structured consideration of each characteristic. For the purpose of this current survey, where areas of reef have been identified, the characteristics specified in Table 2.6.2 were scored, where possible.

In order to obtain a rough estimate of the height of the reef, the distance of the base of the low visibility system (ELViS) from the ground was set and measured prior to commencing the survey. In the current survey the base of the ELViS was positioned 3.5cm off the ground. Therefore, a rough estimate of the height of the reef could be obtained, with a score of >3.5cm assigned if the base of the ELViS touched the reef or <3.5cm high assigned if not.

**Table 2.6.2 Analysis of Characteristics and Score Allocated for the Lynn and Inner Dowsing Survey**

| Characteristic       | Analysis of characteristics and score allocated for the Lynn and Inner Dowsing Survey   |
|----------------------|---|
| <b>Elevation</b>     | The base of the low visibility system is positioned approximately 3.5cm above the seabed to minimise damage to the seabed communities. Therefore, a rough estimate of the height of the reef can be obtained. The elevation of the reef will be given a score of >3.5cm height or <3.5cm height.  |
| <b>Patchiness</b>    | <p>The video footage obtained from the present survey were not video transects and as such the position and the number of seabed drops varies between sites due to the nature of each site. Therefore, patchiness is determined on a site by site basis and is quantified as a percentage and was calculated as follows:</p> $\frac{\text{Total percentage of Sabellaria cover over the whole site}}{\text{Total number of video drops for the site (i.e the total area surveyed)}} \times 100$ |
| <b>Consolidation</b> | A score for this characteristic is difficult to ascertain from the video footage obtained for this survey. For the purpose of this survey, a brief description of the nature of the reef will be given, but descriptive terms used do not relate to the Hendrick & Foster-Smith (2006) scoring system.  |
| <b>Density</b>       | A score for this characteristic is difficult to ascertain from the video footage obtained for this survey. For the purpose of this survey, a brief description of the nature of the reef will be given, but descriptive terms used do not relate to the Hendrick & Foster-Smith (2006) scoring system.  |

In addition, notes were also made on other conspicuous species present.

Stage 3 – Measure of ‘reefiness’

Whilst Hendrick & Foster-Smith (2006) provided a starting point in evaluating reefiness, JNCC have since conducted a workshop (2007) and produced ‘*Defining and managing Sabellaria spinulosa reefs: Report of an inter-agency workshop*’ (JNCC Report 405. Gubbay, 2007). The main focus of the workshop was seeking agreement on a definition of *Sabellaria spinulosa* reefs.

Participants agreed that the simplest definition of *Sabellaria spinulosa* reef in the context of the Habitats Directive was considered to be an area of *Sabellaria spinulosa* which is elevated from the seabed and has a large spatial extent (two of the characteristics presented by Hendrick & Foster-Smith, 2006). Colonies may be patchy within an area defined as reef and show a range of elevations. In addition the report states that, regardless of extent, patchiness appears to be a feature of reefs and therefore 100% coverage should not to be expected within an area defined as a *Sabellaria spinulosa* reef (Gubbay, 2007).

In seeking to provide greater guidance, the workshop participants tried to put some figures on the characteristics of elevation and patchiness which could be used in combination to determine whether an area might qualify as a reef. The best, but not unanimous, agreement which could be reached on the day is given below in Table 2.6.3.

**Table 2.6.3 Range of Figures Proposed by Participants of the JNCC 2007 Workshop, which could be used together as a measure of reefiness.**

| Measure of 'reefiness'               | NOT a REEF | LOW    | MEDIUM | HIGH |
|--------------------------------------|------------|--------|--------|------|
| Elevation (cm) (average tube height) | <2         | 2-5    | 5-10   | >10  |
| Patchiness (% cover)                 | <10%       | 10-20% | 20-30% | >30% |

Note that the figures presented in the table are a starting point for wider discussion rather than accepted and fully agreed thresholds for *Sabellaria spinulosa* reef identification.

***Interpretation of Mytilus edulis and Ampelisca diadema Aggregations***

Although *Sabellaria* was of particular interest in the current study, *Mytilus edulis* beds and *Ampelisca diadema* aggregations were also recorded and their extents estimated. As with the *Sabellaria* aggregations, video footage was analysed for sediment type in those areas *Mytilus edulis* and *Ampelisca diadema* occurred and the aggregations characteristics were described.

The percentage of live and dead individuals was assessed for mussel aggregations, their density and the degree of patchiness. Patchiness estimates were calculated utilising the technique developed for *Sabellaria* (see Table 2.6.2). Dense aggregations of mainly live, small individuals were defined as seed mussel beds. Where the feature consisted of assemblages of large, primarily dead mussel shells and was very patchy in its distribution it was classified as an 'old mussel patch'.

*Ampelisca* aggregations were described on the basis of their density, height and patchiness. As with *Mytilus* aggregations, patchiness estimates were calculated utilising the technique developed for *Sabellaria* (see Table 2.6.2). Where tube mats were dense and a continuous feature they were described as *Ampelisca* reef.

### **3.0 RESULTS**

Data results from the survey are presented in this section. Reference has been made to the various supporting information and drawings in the appendices.

#### **3.1 Hydrographic and Geophysical Data Collection**

The horizontal positioning data from the DGPS system were of good quality throughout the survey period. Navigation checks (detailed in section 2.1.2) showed the positioning systems were working within the expected tolerances. On occasions where line keeping could not be maintained, usually due to the presence of lightbuoys, infill lines were run to ensure complete coverage of the site.

The bathymetric data collected for this report were of very high quality. For periods of the survey the weather deteriorated below the level at which acceptable data could be acquired. During these times the vessel returned to port or the survey was temporarily halted until conditions improved. The decision to stop surveying was made in the field based on the observed conditions. The weather conditions that prevented the collection of survey data were generally wind speeds greater than Force 4 or a significant wave height greater than 1m. No other problems were encountered whilst collecting the data.

The two sources of tidal height data (PPK and BODC tide gauge data at Skegness) compared favourably (Appendix C) and as a result the bathymetric data were reduced using the PPK GPS tidal heights.

The sidescan data collection was occasionally hindered by adverse weather conditions which rendered data unusable. Lines which were unacceptable were re-run in order to provide a complete dataset. In some areas (notably the western ends of the cable routes), water depths became so shallow as to inhibit obtaining full insonification. This was overcome by conducting extra infill lines.

No major problems were encountered during the data collection of the multibeam acoustic backscatter data.

## 3.2 Swath Bathymetry Data

Post-processing of the bathymetric data was performed in QINSy post-processing software, which included the Qloud 3D area based cleaning module. As part of the processing procedure the data were cross-referenced with historical bathymetric data and Admiralty Chart data. The historical data was drawn from reports by Sotheran *et al* (2005), Emu Ltd (2008), Emu Ltd (2007) and Emu Ltd (2005).

### 3.2.1. Bathymetry of Main Site

The bathymetric data for the main survey area have been plotted and are presented in drawing J.1.02.1495.02a. This data has been sun-illuminated with colour shading and 1m contours showing depth below CD Skegness.

Depths within the survey area ranged between 4.0m and 16.5m below CD Skegness. Water depths were shallowest in the west of the area, as the cable routes run towards the shore, with a minimum reading of 4.0m below CD. Most of the site was relatively flat shallow shoal between 5m and 10m below CD gradually sloping to the east of the site. In the south-east there is a more pronounced drop-off with depths increasing from 10m to 16m below CD.

For most of the survey area there are few natural features. In the main shallow shoal area there are small irregular hummocks and troughs which have possibly been caused by wave and tide action. To the south of the site finer sandy gravel areas are associated with large shallow hollows that run in a north-east to south-west direction which coincides with the dominant tidal direction. Further to the south-east a gravely sand area running north-east to south-west identified in sidescan sonar and multibeam acoustic backscatter data is observed in the form of shallow sand waves in the bathymetry data. In the area of the cable runs small sand waves are observed with their long-axis running north-east to south-west. These features, which are also observed in sidescan sonar and multibeam acoustic backscatter, are probably wave-generated.

From the bathymetric data alone it was not possible to determine reef and mussel bed boundaries. However, some of the patchy formations observed in the sidescan sonar data could be seen, particularly in the dense old mussel patch areas to the west and south-west of the surveyed areas. When analysing the data alongside the sidescan and multibeam acoustic backscatter data it was only possible to determine the most likely areas of reef, seed mussel beds and old mussel patches. These are visible predominately in the north, north-west, east and south-west areas of the main survey site.

Across the main site indentation marks from the six legs of the turbine installation vessel *TIV Resolution* could clearly be seen, this coincided with the sidescan data and proved to be an efficient quality check when analysing and comparing both datasets. The bathymetry also detected scour around each individual turbine and can be seen in the bathymetry chart. The average extent of the scour pits is 10.7m in diameter and 1m in depth. The extent of each individual scour pit is documented in Appendix E.

It was also possible to identify in some places the cables which lead from the cable routes to the turbines. Again, these features proved to be a valuable data quality check between sidescan sonar and multibeam bathymetry datasets. Mattressing on the cables near to the turbines is not immediately discernable from the bathymetry whereas it can be seen clearly from the sidescan sonar.

### *Comparison with historical data*

Previous bathymetric surveys that encompassed areas of the main site surveyed this year included Sotheran *et al* (2005), Emu Limited (2008) and Emu Limited (2005).

Only the Sotheran *et al* (2005) survey covered the entire site but unfortunately it appeared that Skegness chart datum had not been used and so a direct like-for-like comparison was not possible. A relative comparison was possible, however, which showed that there were no differences between the datasets outside the IHO Order 1 tolerances of +/- 0.5m for each dataset. Therefore, it can be implied that no major changes in the bathymetry of this site has occurred between surveys. Any small differences between surveys are probably a result of variations in the tidal values used.

The Emu Ltd (2008) survey covered the proposed Lincs wind farm area to the east of this years survey. However, there were areas of overlap to the south-east and to the north-east of the main site. Differences observed were within the allowable IHO Order 1 tolerances of +/- 0.5m for each dataset.

The Emu Ltd (2005) survey used a single-beam echo-sounder and again there was only a small amount of overlap to the east of the main site. Comparisons with this data set showed close agreement and so although the 2009 and 2008 datasets were both within IHO Order 1 height tolerances, this years dataset was considered to be more consistent.

#### **3.2.1 Bathymetry of Sand Wave Area**

The bathymetric survey of the sand wave area, north-east of the main site covered an area of approximately 800m x 800m and is presented in drawing J.1.02.1495.02b. Depths ranged from 11.6m to 15.8m The deepest region was found towards the centre of the survey area. This was also the location of the largest of the three sand waves identified in the area.

Comparison with Emu Ltd (2008) data showed good correlation confirming the reliability of this year's survey. All three sand waves were observed to have moved approximately 50m in a southerly direction from the time of the previous survey in January 2008.

#### **3.2.2 Bathymetry of Lincs Substation**

The proposed Lincs Substation survey area was approximately 200m x 150m in area and is presented in drawing J.1.02.1495.02e. This was a flat area of seabed with depths ranging from 9.2m to 9.6m below CD Skegness. A comparison with Emu Ltd (2008) data showed close agreement, well within the acceptable tolerances for IHO Order 1 surveys.

#### **3.2.3 Bathymetry of Docking Shoal Met Mast**

The Docking Shoal met mast survey area was approximately 180m x 180m centred around the met mast and is presented in drawing J.102.1495.02c.

Scour could be observed to extend approximately 40m in an east-southeast direction. This scour had a maximum depth of approximately 1.6m deeper than the surrounding seabed. This depth was confirmed by comparing with Emu Ltd (2007) data.

A large sand wave over 1m in height was observed approximately 50m north of the met mast running in a west to east direction. A comparison with Emu Ltd (2007) data showed that this had moved approximately 20m north between surveys.

Comparison with the Emu Ltd (2007) data showed that the seabed at this location was relatively dynamic. However, overall the data was seen to be well within the acceptable IHO Order 1 tolerances. In addition to the scour and the sand wave, a mound to the east of the met mast had appeared between surveys. The maximum height of this mound was approximately 0.8m above the height of the surrounding seabed.

### **3.2.4 Bathymetry of Race Bank Met Mast**

The Race Bank met mast survey area was approximately 100m x 180m centred around the met mast and is presented in drawing J.1.02.1495.02d. A comparison with the Emu Ltd (2007) survey showed that this area of seabed was relatively dynamic but with approximately half the area being deeper and half the area shallower, there was confidence in the reliability of this years survey.

Scour was observed to extend approximately 40m in an easterly direction with a maximum depth of 2m compared with the surrounding seabed. To the north-west corner of the surveyed area the seabed was observed to have become deeper by up to 1.5m. Over the rest of the site it was clear that dynamic processes had affected the seabed with some areas deeper by up to 1.4m and some areas shallower by up to 0.8m.

### 3.3 Sidescan Sonar Data

Following processing, the sidescan sonar data were cross referenced with the bathymetric data to provide a bulk positional accuracy check. In the absence of previous sidescan interpretation data a comparison was not possible. A general comparison with old Acoustic Ground Discrimination System (AGDS) and bathymetric data was conducted to check for any gross changes in the seafloor i.e. sand banks or scour around turbine bases.

The high resolution sidescan sonar data have been used to supplement the bathymetry, multibeam acoustic backscatter data and video and grabbing data in providing seabed and biotope classification as well as to identify any items of debris, wrecks or other seabed features. The processed data have been mosaiced and presented in Drawing J.1.02.1495.03. A seabed features chart has been produced using the sidescan sonar, multibeam acoustic backscatter, video and grabbing data and is presented in Drawing J.1.02.1495.04. A seabed contacts list is included in Appendix F.

Data quality throughout the area was very good. Four main seabed types have been classified from the combined datasets with boundaries identified from the sidescan sonar data. PSA data was taken from Sotheran *et al* (2005) data which was cross referenced with field observations. The main seabed types identified are:

- GRAVEL
- Sandy Coarse GRAVEL
- Sandy GRAVEL
- Gravelly SAND

The changes in the character of seabed sediment that occur within the surveyed area are not major. The sidescan sonar mosaic shows areas of relatively high reflectivity due to its rough texture, indicating coarser sediment. Ground truthing of these areas of high reflectivity has confirmed that this is gravel. The gravel is located along the central region of the wind farm site, on a north-south axis. There is a distinct difference in reflectivity across the majority of the site. Ground truthing has revealed that these areas are gravelly sand, sandy gravel and sandy coarse gravel. The areas of higher reflectivity, which are darker in shade, represent sandy coarse gravel, which has a higher proportion of gravel particles that are larger in size. The lighter areas represent areas of lower sonar reflectivity represented areas of finer material. Where there are sandwaves present, the majority of the sediment is gravelly sand. Outside the areas of sandwaves, the sediment type is sandy gravel that has a lower proportion of gravel particles compared to the sandy coarse gravel.

The areas of sandwaves are aligned in a north east to south-west trend, which appeared to coincide with the dominant tidal direction. The size of these individual sandwave 'ribbons' varies across the site with some being up to 300m wide and some only a few metres wide. The widest sandwave formation occurs on the western end of the cable routes.

Within the survey area patchy formations are present that may indicate the presence of biogenic features. However, it was not possible from sidescan sonar, acoustic backscatter or bathymetry data to specifically identify areas of old mussel patch, seed mussel beds and low lying *Sabellaria* reef. Drop down video was used to identify these formations and where a sample was taken in a delineated biogenic area, this area could be classified accordingly. Where no ground truthing had been performed in a delineated area, the area encompassed could only be classified as 'likely areas of *Sabellaria* reef, seed mussel or old mussel patches'. These areas are highlighted in the interpretation chart J.1.02.1495.04 and are further discussed in Section 3.5.

The sidescan sonar data do not show significant man-made debris or wrecks. From the Admiralty Chart, there is a wreck within the site at position 53° 10' 29.9" N 000° 27' 39.5" E but no evidence of this was observed in the sidescan sonar data. The majority of the identified contacts are possible boulders and man-made debris. There was evidence of extensive trawling activity in the central region of the site. The locations of contacts are plotted with positions including examples of seabed types, on the sidescan sonar mosaic drawing J.1.02.1495.03a and included in Appendix F. Smaller sized debris may exist but was not resolvable from the sidescan sonar data set.

It is also possible on the sidescan mosaic to identify the locations of a number of the cables running across the windfarm site and cable routes. These have been picked out and represented on the interpretation. Six identical areas of indentation marks can be seen to the north of each turbine. These were created by the six legs of the turbine installation vessel *TIV Resolution*.

### 3.4 Multibeam Acoustic Backscatter Data

The Acoustic Ground Discrimination System (AGDS) used for this survey was multibeam acoustic backscatter derived from a Reson 8101 multibeam echosounder. This was processed as described in Section 2.4 The resulting GeoTIFF was plotted and is presented in drawing J.1.02.1495.05.

Extensive processing using the QTC MULTIVIEW processing software was required to output data most representative of the seabed as determined from sidescan sonar, bathymetry and ground truthing information. As part of this processing it was found that data collected in two areas of the main survey area adversely affected the overall analysis within the software. It was decided to leave these areas out of the final processed solution to help better define the majority of the data. These areas were a strip approximately 150m wide in the south-east of the site and a strip approximately 180m wide to the south-west of the site. It is not thought that these omissions have greatly reduced the overall value of the data presented.

The seabed classes derived from the QTC MULTIVIEW processing software were classified based on ground truthing and sidescan sonar data. It was only possible to differentiate three classes from this dataset. It is thought that this was because of the low acoustic variability across the site. A description of each class has been presented below:

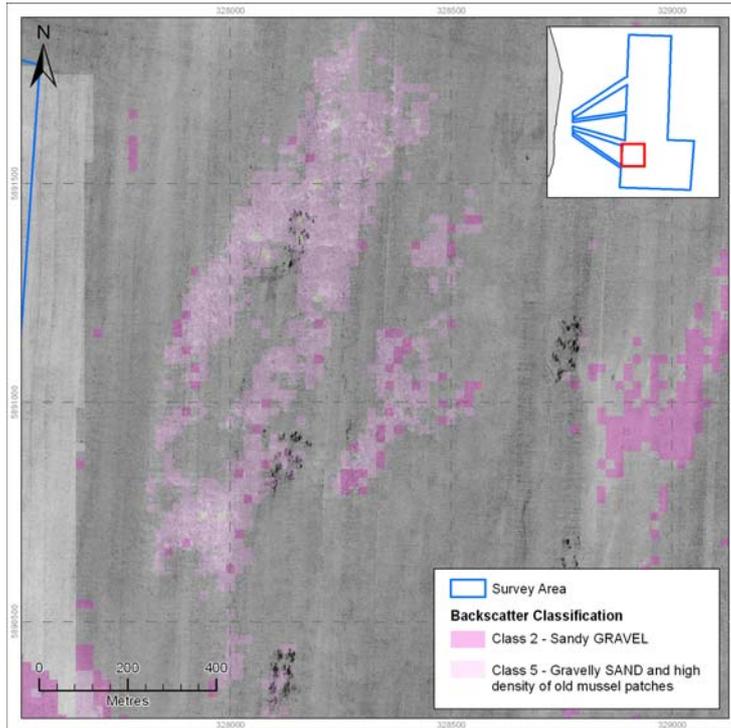
**Table 3.4.1. Classes of multibeam acoustic backscatter**

| Class | Colour     | Description  |
|-------|------------|--|
| 2     | Dark Pink  | Sandy GRAVEL   |
| 3     | Green/Grey | GRAVEL and sandy coarse GRAVEL                       |
| 5     | Light Pink | Gravelly SAND and high density of old mussel patches |

Class 3 covers most of the site and indicates the low acoustic variability across the site. Class 2 and Class 5 show finer sediment characteristics with Class 5 also showing areas of high density old mussel patches.

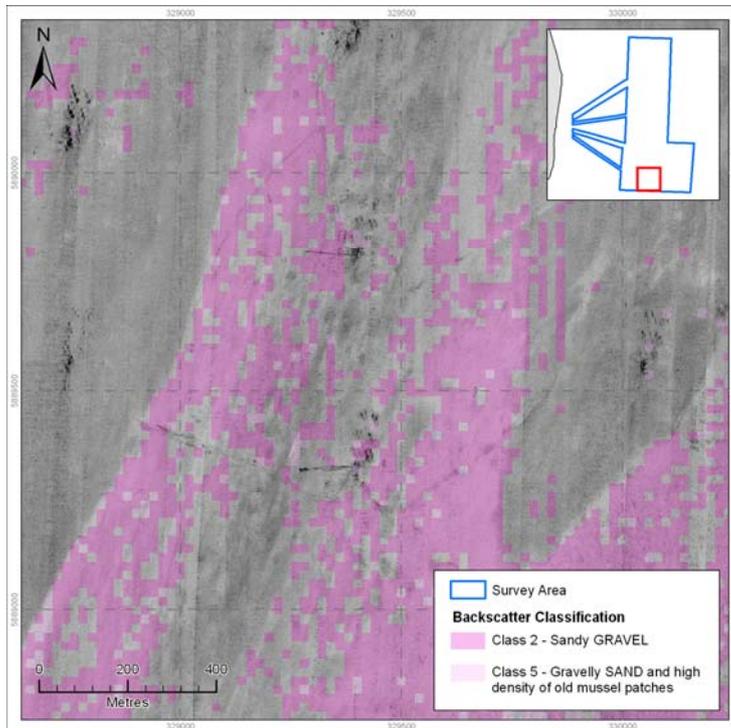
It has not been possible to clearly differentiate distinct low lying *Sabellaria* reef, *Sabellaria* aggregations, seed mussel beds or old mussel patches from the multibeam acoustic backscatter data. It is thought that this is partly to do with the low acoustic variability across the site (as also observed in the sidescan sonar data) and also the fact that the low lying reef identified from the ecological ground truthing survey was not well defined. However, the acoustic backscatter data were able to differentiate predominant areas of interest in the north, north-west, east and south-west areas of the main survey site. The data also confirmed the area of sandwaves extending in a north-easterly direction in the south-east of the main survey area and features in the far western extent of the cable routes.

The following figures show example comparisons between the multibeam acoustic backscatter data and the sidescan sonar data. In these figures Class 3 has been removed with Class 2 and Class 5 being made transparent, overlaying the sidescan sonar mosaic.



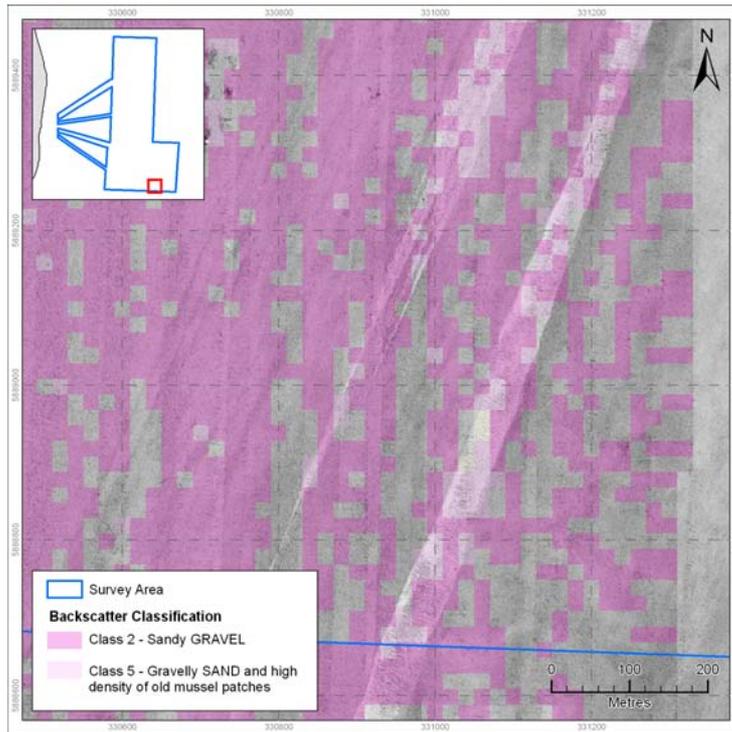
**Figure 3.4.1. Multibeam acoustic backscatter data highlighting a dense area of old mussel patches**

Figure 3.4.1. shows a dense area of old mussel patches located to the south-west of the site highlighted as Class 5 from the multibeam acoustic backscatter data. A small area of finer sediments to the east of the image can also be seen.



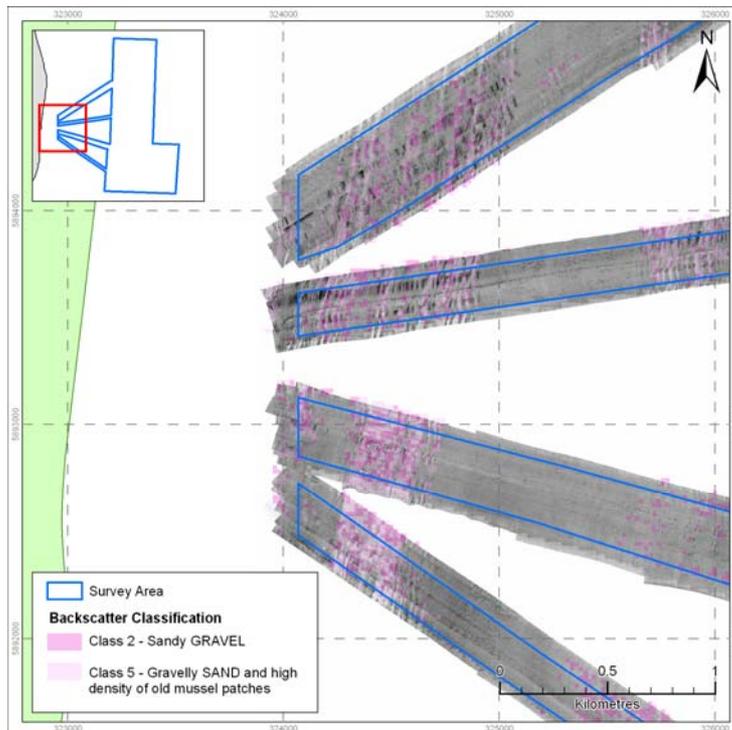
**Figure 3.4.2. Multibeam acoustic backscatter highlighting a boundary between different sediment types**

Figure 3.4.2. shows a clear boundary between sandy coarse gravel and sandy gravel located in the south of the main site. The sandy gravel has been classified as Class 2 in the multibeam acoustic backscatter, processed dataset.



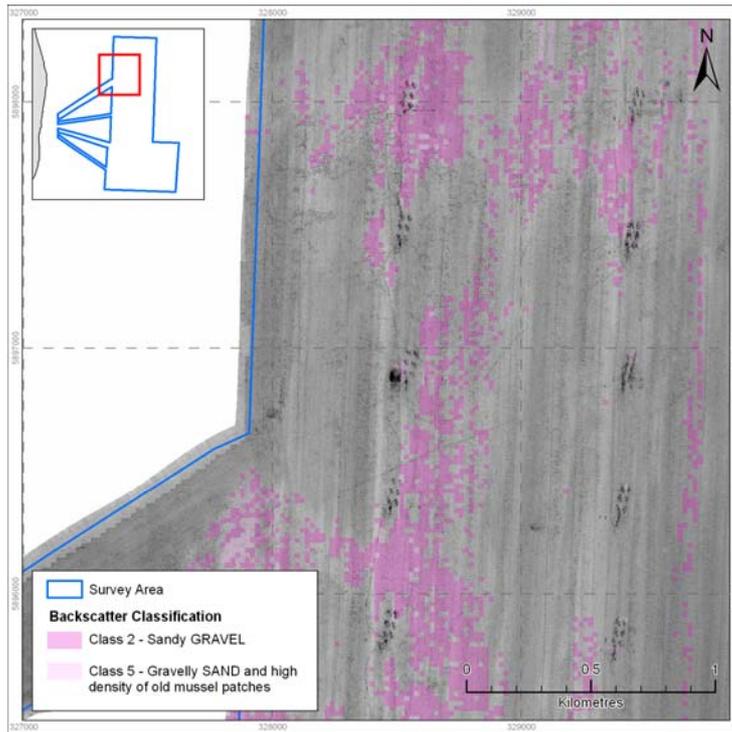
**Figure 3.4.3. Multibeam acoustic backscatter highlighting a sand wave area**

Figure 3.4.3. shows the sand wave area to the south-east of the main site. The sandy gravel is shown as Class 2 and the finer gravelly sand is shown as Class 5.



**Figure 3.4.4. Multibeam acoustic backscatter highlighting the sand wave areas on the cable routes**

Figure 3.4.4 shows the finer sediments associated with the sand wave areas identified on the cable routes. The sandwaves are predominantly defined as gravelly sand with small areas of sandy gravel.



**Figure 3.4.5. Multibeam acoustic backscatter highlighting different sediments and a possible area of low lying *sabellaria* reef**

Figure 3.4.5. is from the north-west of the site. The centre and south areas highlighted as Class 2 show the boundary between different sediment types. To the north of the image is an area of possible low lying *Sabellaria* reef. It was not possible to determine if the presence of the Class 2 in this region was attributable to the presence of *Sabellaria* or represents a difference in the sediment type.

### 3.5 Drop Down Video and Grab Data

#### *Grab survey results*

Table 3.5.1 below contains the grab site locations and depths together with an illustrative photo of each sample.

Detailed results from the grab survey are included in Appendix H. Ten grab samples were taken by Emu Ltd for a more detailed assessment of sediment type. These were used to verify the PSA data detailed in Sotheran *et al.* (2005), which was the primary source of information used to classify the sediment types interpreted from sidescan sonar. Deck photos of the grab samples are contained in Table 3.5.1 and included in Appendix N.

**Table 3.5.1. Grab site locations, water depths & deck photos**

| Site No. | Location (lat/long)       | Water Depth (m) | Image  |
|----------|---------------------------|-----------------|--|
| 7        | 53.181335 N<br>0.406337 E | 7.1             |   |
| 12       | 53.150039 N<br>0.415658 E | 11.1            |  |
| 14       | 53.138712 N<br>0.406215 E | 8.4             |  |
| 15       | 53.137272 N<br>0.414085 E | 10.2            |  |

| Site No. | Location (lat/long)       | Water Depth (m) | Image |
|----------|---------------------------|-----------------|-------|
| 16       | 53.168781 N<br>0.375421 E | 9.3             |       |
| 18       | 53.125180 N<br>0.421695 E | 15.3            |       |
| 27       | 53.124398 N<br>0.492311 E | 18.9            |       |
| 28       | 53.143974 N<br>0.493309 E | 18.6            |       |
| 33       | 53.141906 N<br>0.463747 E | 15.5            |       |

| Site No. | Location (lat/long)       | Water Depth (m) | Image  |
|----------|---------------------------|-----------------|--|
| 36       | 53.167969 N<br>0.438217 E | 9.9             |    |
| 40       | 53.193919 N<br>0.453231 E | 10.3            |    |
| 42       | 53.207069 N<br>0.442558 E | 13.9            |   |
| 43       | 53.208849 N<br>0.430144 E | 13.6            |  |
| 44       | 53.204352 N<br>0.426523 E | 13.4            |  |

| Site No. | Location (lat/long)       | Water Depth (m) | Image  |
|----------|---------------------------|-----------------|--|
| 45       | 53.208986 N<br>0.463036 E | 10.6            |    |
| 46       | 53.171511 N<br>0.464431 E | 11.6            |    |
| 47       | 53.157478 N<br>0.446738 E | 11              |   |
| 49       | 53.164077 N<br>0.461688 E | 11.6            |  |

### *Drop Down Video and Stills Analysis*

The video footage collected provides an overview of the seabed within the Lynn and Inner Dowsing wind farm array area. The video log and underwater stills images can be found in Appendices G and N respectively. The static images and video footage were used to identify and classify areas of *Sabellaria spinulosa* aggregations and describe *Mytilus edulis* and *Ampelisca diadema* agglomerations. Video data were also used to ground truth the sediment types interpreted from the sidescan sonar data.

The sediment characteristics and *Sabellaria spinulosa*, *Mytilus edulis* and *Ampelisca diadema* aggregation data recorded from video footage obtained from the 38 sites across the survey area are presented in Table 3.5.2. For video sites where grab sampling was also undertaken, the resulting information on aggregations is included within Table 3.5.2. Conspicuous species are also noted. A more detailed record from the video and stills analysis can be found in Appendix I.

Patchiness scores for *Sabellaria spinulosa* reef are based on the ‘Absolute percentage *Sabellaria* reef’ scores contained in Appendix I. These were calculated by attributing a percentage of *Sabellaria* reef to each of the photos analysed for a site and then dividing the total percentage by the number of images analysed. For example:

- Photo 1 – 40% *Sabellaria* reef
- Photo 2 – 25% *Sabellaria* reef
- Photo 3 – 25% *Sabellaria* reef

|  |     |
|--|-----|
| Total percentage:                              | 90% |
| Number of photos:                              | 3   |
| Absolute percentage of <i>Sabellaria</i> reef: | 30% |

Other forms of *Sabellaria* aggregation, including tubes, crusts and clumps, were not included in the calculation for the ‘Absolute percentage of *Sabellaria* reef’. Instead, a separate score for percentage cover of non-reef aggregations was calculated using a similar method.

**Table 3.5.2** Video and stills image analyses results and 3 stage analysis of *Sabellaria* aggregations.

**\* Note<sup>1</sup>:**

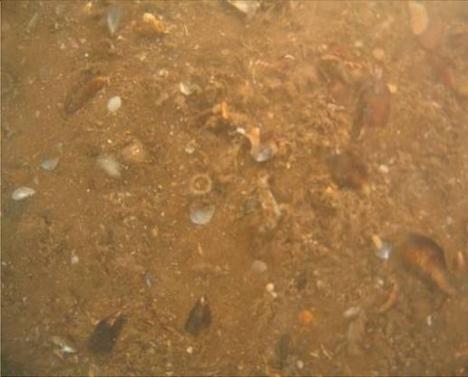
*Sabellaria* reef patchiness scores are based on the Absolute percentage of *Sabellaria spinulosa* reef scores contained in Appendix I. Absolute percentage of *Sabellaria spinulosa* reef refers to the total percentage of *Sabellaria* reef present in all photos analysed for a site, divided by the total number of photos. Percentages of other *Sabellaria* forms, including tubes, crusts and clumps, are not included in this score. A separate absolute percentage cover score is given for these aggregation types.

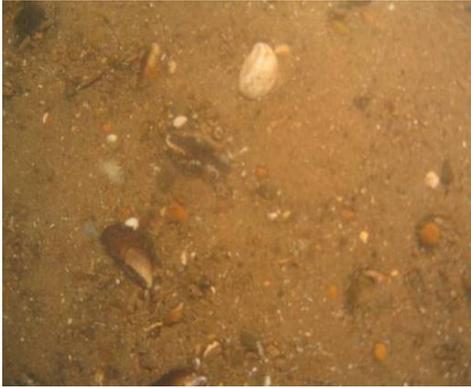
**\* Note<sup>2</sup>:**

For sites where grab sampling was also undertaken, the resulting information on aggregations is included.

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description  | Stage 2 analysis   |                |                 |                           |   | Image  | Stage 3 analysis                                     |   |
|------|--|--|----------------|-----------------|---------------------------|---|--|--|---|
|      |  | Form   | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  | <i>Sabellaria</i> reef definition based on Elevation | <i>Sabellaria</i> reef definition based on Patchiness |
| 6    | Slightly gravelly shelly silty sand with occasional pebbles.<br><br>Old mussel patch - lots of dead <i>Mytilus edulis</i> shells.<br>4% absolute percentage of live individuals. | Moribund loose tubes and small amount of Crusts on shells and sediment (2% cover).<br><br>No reef. | *              | *               | *                         | Hydrozoan / Bryozoan turf, <i>Pomatoceros</i> sp., <i>Flustra foliacea</i> , Anthozoan sp., Bryozoan crust, <i>Hydrallmania falcata</i> . |  | NOT SABELLARIA REEF                                  | NOT SABELLARIA REEF                                   |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description  | Sabellaria characteristics                              |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|--|---|----------------|-----------------|---------------------------|---|--|---|--|
|      |  | Form  | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 8    | Slightly silty sandy gravel with pebbles and some cobbles.   | Moribund loose tubes (10% cover).<br>No reef.           | x              | x               | x                         | <i>Frustra foliacea</i> , Hydrozoan / Bryozoan turf, <i>Pomatoceros</i> sp., <i>Macropodia</i> sp., <i>Asterias rubens</i> , Decapod sp., <i>Crepidula</i> sp., <i>Porifera</i> sp., <i>Sabella</i> tubes |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 9    | Shelly silty sandy gravel. Old mussel patch with dense patches of dead mussel shells. 10% - absolute percentage of live individuals. | Moribund loose tubes and Crusts (6% cover).<br>No reef. | x              | x               | x                         | Hydrozoan / Bryozoan turf <i>Pomatoceros</i> sp., Bryozoan crust., <i>Crossaster papposus</i> , Decapod sp.   |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description  | Sabellaria characteristics  |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|--|---|----------------|-----------------|---------------------------|---|--|---|--|
|      |  | Form  | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 10   | <p>Slightly gravelly shelly mobile sand. Sand, waves/ripples present.</p> <p>Scattered mussel shells with few possibly live individuals. Some possibly alive (absolute percentage 1%).</p> | <p>Moribund loose tubes and Crusts on shells and sediment (1% cover).</p> <p>No reef.</p> | x              | x               | x                         | None  |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 11   | <p>Shelly slightly silty sand with some gravel patches.</p> <p>Old mussel patch with scattered dead mussel shells. Absolute percentage of live individuals 3%).</p>                        | <p>Moribund loose tubes and Crusts (2% cover).</p> <p>No reef.</p>                        | x              | x               | x                         | <p>Antho<sup>o</sup>oa sp.<br/>Pomatoceros sp.<br/>Hydro<sup>o</sup>oan / Bryo<sup>o</sup>oan turf, <i>Crepidula fornicata</i>.</p> |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description   | Sabellaria characteristics                              |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|---|----------------|-----------------|---------------------------|---|--|---|--|
|      |   | Form  | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 13   | <p>Slightly shelly gravelly mobile sand. Sand ripples present.</p> <p>Scattered mussel shells with few possibly live individuals. Absolute percentage of live individuals (2%).</p>                                 | <p>Moribund loose tubes (2% cover).</p> <p>No reef.</p> | *              | *               | *                         | <i>Anseropoda placenta</i>  |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 14   | <p>Gravelly silty sand.</p> <p>Ampelisca reef. Med-high density and abundance. 3.5cm proud. Absolute percentage 87%.</p> <p>Grab results for <i>Ampelisca</i> 1.5cm high, 5% percentage cover within grab bite.</p> | Absent  | *              | *               | *                         | <p><i>Ampelisca diadema</i>,<br/><i>Ophiura albida</i>,<br/><i>Pomatoceros</i> sp.,<br/><i>Anthozoa</i> spp.,<br/><i>Macropodia</i> sp.,<br/>Hydrozoan / Bryozoan turf, <i>Sabella</i> sp., <i>Ophiura</i> sp.,</p> |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description                    | Sabellaria characteristics  |  |                 |  |  | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|--|---|--|-----------------|--|--|--|---|--|
|      |  | Form  | Reef Elevation   | Reef Patchiness | Brief description of reef  | Other conspicuous species  |  |   |  |
| 16   | Slightly shelly sand with some pebbles. Sand ripples/waves present.                                      | Crusts and Clumps (4% cover).<br>Potential reef (not a continuous feature) (12% cover). | ±3.5cm<br><i>Sabellaria</i> in grab 4cm high. 2 clumps, each 4cm across. Percentage cover within grab bite ±5% | 12%             | Clumps and crusts of <i>Sabellaria</i> and low lying reef. Low-med consolidation, abundance and density. | <i>Cirripedia</i> sp., <i>Antho</i> oa sp., <i>Urticina</i> sp.<br>Hydrozoan / Bryozoan turf |   | LOW   | LOW  |
| 17   | Slightly shelly mobile sand. Sand waves/ripples present.<br>Scattered <i>Mytilus edulis</i> (±2% cover). | Moribund loose tubes, Crusts and Clumps - little consolidation (3% cover).<br>Not reef. | x  | x               | x  | <i>Liocarcinus</i> sp.,<br>Hydrozoan / Bryozoan turf, Bryozoan crust, <i>Pomatoceros</i> sp. |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description                                       | Sabellaria characteristics |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|----------------------------|----------------|-----------------|---------------------------|---|--|---|--|
|      |   | Form                       | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 18   | Gravelly silty sand.<br>Ampelisca clumps and patchy reef. □3.5cm proud. Med density and abundance. Absolute percentage 10□. | Absent                     | *              | *               | *                         | <i>Ampelisca diadema</i> ,<br><i>Sabella</i> tubes, <i>Ophiura albida</i> , Hydrozoan / Bryozoan turf, <i>Flustra foliacea</i> , <i>Pomatoceros</i> sp., <i>Asterias rubens</i> , <i>Anthozoa</i> sp. |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 19   | Gravelly silty sand   | Absent                     | *              | *               | *                         | <i>Asterias rubens</i> ,<br>Hydrozoan / Bryozoan turf, <i>Ophiura albida</i> , <i>Sabella</i> tube, <i>Ophiura</i> sp.,   |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edilus</i> / <i>Ampelisca diadema</i> aggregation description                   | Sabellaria characteristics |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|----------------------------|----------------|-----------------|---------------------------|---|--|---|--|
|      |   | Form                       | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 20   | Shelly muddy sand.<br>Patches of old, large mussels, appear to be mainly dead (absolute percentage 7%). | Absent                     | *              | *               | *                         | Bryozoan crust, <i>Pomatoceros</i> sp., Hydrozoan / Bryozoan turf, <i>Flustra foliacea</i>  |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 21   | Muddy sand with some shell.<br>Old mussel patch (absolute percentage 28%).                              | Absent                     | *              | *               | *                         | <i>Pomatoceros</i> sp., Bryozoan crust, <i>Asterias rubens</i> , Hydrozoan / Bryozoan turf, |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edilus</i> / <i>Ampelisca diadema</i> aggregation description                           | Sabellaria characteristics                                  |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|---|----------------|-----------------|---------------------------|---|--|---|--|
|      |   | Form  | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 22   | Slightly shelly muddy sand with occasional gravel.<br><br><b>Old mussel patch</b><br>(absolute percentage 17%). | Crusts (1% cover).<br><br>No reef.                          | x              | x               | x                         | <i>Hydrozoa</i> spp., <i>Asterias rubens</i> , <i>Bryozoan</i> crust,                       |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 23   | Shelly silty sandy gravel.<br><br>Old mussel patch with scattered dead mussels. No live individuals apparent.   | Moribund loose tubes and Crusts (4% cover).<br><br>No reef. | x              | x               | x                         | <i>Pomatoceros</i> sp. Hydrozoan / Bryozoan turf, <i>Anthofoa</i> sp., <i>Sabella</i> tube. |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description | Sabellaria characteristics                   |                |                 |                           |  | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|--|----------------|-----------------|---------------------------|--|--|---|--|
|      |   | Form   | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species  |  |   |  |
| 24   | Gravelly silty sand with some pebbles.  | Moribund loose tubes (1□ cover).<br>No reef. | x              | x               | x                         | <i>Crossaster papposus</i> ,<br>Hydrozoan / Bryozoan turf, <i>Pomatoceros</i> sp.,<br><i>Flustra foliacea</i> , <i>Ophiura albida</i> , <i>Ophiura</i> sp. |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 25   | Slightly shelly, slightly gravelly silty sand.  | Moribund loose tubes (3□ cover).<br>No reef. | x              | x               | x                         | <i>Ophiura albida</i> ,<br>Hydrozoan / Bryozoan turf, Anthozoa sp.,<br><i>Ophiura</i> sp.  |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description | Sabellaria characteristics   |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|--|----------------|-----------------|---------------------------|---|--|---|--|
|      |   | Form   | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 26   | Silty sandy gravel with pebbles and occasional cobble.                                | Moribund loose tubes and encrusting sediment (1% cover).<br><br>No reef. | x              | x               | x                         | <i>Pomatoceros</i> sp., Hydrozoan/bryozoan turf, <i>Calliostoma</i> sp., <i>Pygospio</i> , <i>Flustra foliacea</i> .  |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 27   | Slightly gravelly, slightly shelly silty sand with occasional pebbles.                | Moribund loose tubes and encrusting sediment (4% cover).<br><br>No reef. | x              | x               | x                         | <i>Urticina</i> sp., <i>Macropodia</i> sp., Hydrozoan/bryozoan turf, <i>Pomatoceros</i> sp., <i>Ophiura albida</i> , <i>Crepidula fornicata</i> , <i>Galathea</i> sp. |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edilus</i> / <i>Ampelisca diadema</i> aggregation description   | Sabellaria characteristics  |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|---|----------------|-----------------|---------------------------|---|--|---|--|
|      |   | Form  | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 29   | Slightly shelly sand with pebbles and some cobbles. Sand mobile - some ripples present. | Absent  | *              | *               | *                         | Hydrozoan/Bryozoan turf, <i>Asterias rubens</i> , Hydrozoan/Bryozoan turf, <i>Flustra foliacea</i> , <i>Pomatoceros</i> sp.                             |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 30   | Slightly gravelly, silty sand with some pebbles.  | Moribund loose tubes and encrusting sediment (11% cover).<br><br>No reef. | *              | *               | *                         | <i>Ophiura albida</i> , Hydrozoan/bryozoan turf., <i>Crossaster papposus</i> , <i>Urticina</i> sp, <i>Crepidula fornicata</i> , <i>Flustra foliacea</i> |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description | Sabellaria characteristics  |                |                 |  |  | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|---|----------------|-----------------|--|--|--|---|--|
|      |   | Form  | Reef Elevation | Reef Patchiness | Brief description of reef  | Other conspicuous species  |  |   |  |
| 31   | Slightly shelly mobile sand. Sand waves present.                                      | Moribund loose tubes and a small Clump (2% cover).<br><br>No reef.  | *              | *               | *  | None   |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 32   | Slightly shelly slightly gravelly silty sand.   | Moribund loose tubes and encrusting sediment (6% cover).<br><br>Potential Reef % not a continuous feature (5% cover), | ~3.5cm         | 5%              | Possible lowlying reef, though hard to assess as covered over by sediment. | <i>Antho<math>\square</math>oa</i> sp., <i>Flustra foliacea</i> ,<br><i>Hydro<math>\square</math>oan/Bryo<math>\square</math>oan</i> turf,<br><i>Ophiura albida</i> , <i>Antho<math>\square</math>oa</i> sp., <i>Porifera</i> sp., <i>Majidae</i> sp., <i>Psammechinus miliaris</i> , <i>Asterias rubens</i> . |  | LOW   | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description   | Sabellaria characteristics                              |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|---|----------------|-----------------|---------------------------|---|--|---|--|
|      |   | Form  | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 34   | Gravelly silty sand with occasional pebbles.  | Crusts (1% cover).<br>No reef.                          | *              | *               | *                         | Hydroids / Bryozoan turf, <i>Ophiura albida</i> , <i>Pomatoceros</i> sp., <i>Urticina</i> sp., <i>Flustra foliacea</i> , <i>Paguridae</i> sp. |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 35   | Silty muddy sand with some shell.<br><br>Seed mussel bed. Consisting of smaller, apparently live individuals (absolute percentage 68%). Small patches of <i>Sabellaria</i> crust and possibly moribund loose tubes. | Moribund loose tubes and Crusts (2% cover).<br>No reef. | *              | *               | *                         | Anthoidea sp., Decapod sp., <i>Flustra foliacea</i> , <i>Sabella</i> tubes  |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description  | Sabellaria characteristics  |                |                 |                           |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|--|---|----------------|-----------------|---------------------------|---|--|---|--|
|      |  | Form  | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |  |   |  |
| 37   | Gravelly muddy sand.<br><br>Old mussel patch with <i>Sabellaria</i> tubes and crusts.<br><br>Feature consists primarily of large, old mussels (absolute percentage 40%). Hard to assess if alive/dead. Up to 50% dead. | Crusts (2% cover).<br><br>No reef.  | *              | *               | *                         | <i>Pomatoceros</i> sp.,<br><i>Asterias rubens</i>   |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 38   | Silty sandy gravel with pebbles and occasional cobbles.  | Moribund loose tubes, patchy Crusts and 1 small Clump (8% cover).<br><br>No reef. | *              | *               | *                         | <i>Pomatoceros</i> sp.,<br>Hydrozoan / Bryozoan turf, <i>Asterias rubens</i> ,<br><i>Flustra foliacea</i> , <i>Porifera</i> sp. |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description  | Sabellaria characteristics   |                |                 |   |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|--|--|----------------|-----------------|---|---|--|---|--|
|      |  | Form   | Reef Elevation | Reef Patchiness | Brief description of reef   | Other conspicuous species   |  |   |  |
| 39   | Shelly silty sand.<br><br>Possible mussel and <i>Sabellaria</i> reef feature.<br><br>Feature consists primarily of large, old mussels. Hard to assess if alive/dead. Absolute percentage of mussels 74%. Up to 50% dead. | Moribund loose tubes, Crusts and Clump (3% cover).<br><br>Some potential patchy Reef (3% cover). | ~3.5cm         | 3%              | Low lying reef, low-med density, abundance and consolidation. Possibly moribund in areas. | <i>Sabella</i> spp. Bryozoan / Hydrozoan turf, <i>Asterias rubens</i> , <i>Flustra foliacea</i> , <i>Anthofoa</i> sp., <i>Buccinum undatum</i> , <i>Urticina</i> sp., <i>Pomatoceros</i> sp., <i>Crassoster papposus</i> , <i>Macropodia</i> sp., |   | LOW   | NOT SABELLARIA REEF                            |
| 41   | Silty sandy gravel with pebbles and occasional cobbles.  | Moribund loose tubes and patchy Crusts on sediment (6% cover).<br><br>No reef.                   | *              | *               | *   | <i>Cirripedia</i> sp., Hydrozoan / Bryozoan turf, <i>Flustra foliacea</i> , <i>Asterias rubens</i> , <i>Pomatoceros</i> sp., <i>Porifera</i> sp.  |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edilus</i> / <i>Ampelisca diadema</i> aggregation description   | Sabellaria characteristics  |  |                 |  |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|---|--|-----------------|--|---|--|---|--|
|      |   | Form  | Reef Elevation   | Reef Patchiness | Brief description of reef  | Other conspicuous species   |  |   |  |
| 42   | Silty sandy gravel with pebbles in places.  | Moribund loose tubes, Crusts and Clumps (16% cover).<br><br>Potential Reef not a continuous feature (12% cover).  | ~3.5cm<br><br><i>Sabellaria</i> in grab - clumps, 2cm high. Percentage cover within grab bite ~1%. | 12%             | Not a continuous feature. <i>Sabellaria</i> tubes, crusts, clumps and reef. Some possibly moribund. Low consolidation, low abundance and density. Clumps of <i>Sabellaria</i> in grab (~10cm diameter, low consolidation). | Hydrozoan/Bryozoan turf, <i>Porifera</i> sp., <i>Flustra foliacea</i> , <i>Urticina</i> sp., <i>Majidae</i> sp., <i>Asterias rubens</i> , <i>Sabella</i> tube |   | LOW   | LOW  |
| 43   | Slightly shelly, slightly gravelly silty sand with some pebbles.<br><br>Patches of <i>Ampelisca/Sabellaria</i> mix encrusting sediment. | Crusts (25% cover). In addition, grab sample contained 2 <i>Sabellaria</i> clumps (3cm diameter, 5cm high, ~5% cover within grab bite, little consolidation).<br><br>No reef. | x  | x               | x  | Hydrozoan/Bryozoan turf, <i>Pometoceros</i> sp., <i>Flustra foliacea</i> , <i>Sabella</i> sp., <i>Anthozoa</i> sp.,   |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edilus</i> / <i>Ampelisca diadema</i> aggregation description   | Sabellaria characteristics   |  |                 |  |  | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|---|--|--|-----------------|--|--|--|---|--|
|      |   | Form   | Reef Elevation   | Reef Patchiness | Brief description of reef  | Other conspicuous species  |  |   |  |
| 44   | Gravelly silty sand with some pebbles.  | Crusts and Clumps (15% cover).<br>Potential Reef (not a continuous feature) (37%). | ±3.5cm<br><i>Sabellaria</i> in grab (crusts and potential reef, 2cm high). | 37%             | Not a continuous feature. Mix of <i>Sabellaria</i> crust and reef proud of seabed ±3.5cm. Low/medium abundance and density. Low consolidation. Some areas possibly moribund.<br><i>Sabellaria</i> in grab (little concretion of substratum). | Hydrozoan / Bryozoan turf, <i>Pomatoceros</i> sp., <i>Asterias rubens</i> , <i>Flustra foliacea</i> , <i>Crepidula fornicata</i> , <i>Macropodia</i> sp. |   | LOW   | HIGH   |
| 48   | Silty muddy sand with patches of shell and some gravel.<br>Old mussel patch with <i>Sabellaria</i> tubes and crust.<br>Primarily a mussel patch, consisting of large, old individuals (absolute percentage 55%). Hard to assess if alive/dead. At least 50% dead. | Moribund loose tubes and small patches of Crust (1% cover).<br>No reef.            | *  | *               | *  | Hydrozoan / Bryozoan turf, <i>Buccinum undatum</i> .   |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description  | Sabellaria characteristics                                  |  |                 |   |   | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|--|---|--|-----------------|---|---|--|---|--|
|      |  | Form  | Reef Elevation   | Reef Patchiness | Brief description of reef   | Other conspicuous species   |  |   |  |
| 49   | Silty muddy sand with shell.<br><br>Seed mussel and Sabellaria reef feature.<br><br>Feature consists primarily of smaller, apparently live mussels (absolute percentage 81%), mixed with Sabellaria. | Crusts (1% cover)<br><br>Potential Reef (13% cover).        | ±3.5cm<br><br>Sabellaria in grab ± small clumps, 2cm high. Percentage cover within grab bite ±1% | 13%             | Not a continuous reef. Low-medium consolidation, density and abundance of Sabellaria, Sabellaria crusts and low lying reef present. Clumps (±10cm diameter, low consolidation) in grab. | Antho <sup>zoa</sup> spp. Asterias rubens, Porifera sp., Ophiura albida, Calliostoma <sup>sp.</sup> yphinum, Flustra foliacea, Hydro <sup>zoan</sup> / Bryo <sup>zoan</sup> turf, Buccinum undatum, Shrimp. |   | LOW   | LOW  |
| 50   | Shelly gravelly silty sand.  | Moribund loose tubes and Crusts (6% cover).<br><br>No reef. | *  | *               | *   | Hydro <sup>zoan</sup> / Bryo <sup>zoan</sup> turf, Macropodia sp., Flustra foliacea.  |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description  | Sabellaria characteristics  |                |                 |                           |  | Image  | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|--|---|----------------|-----------------|---------------------------|--|--|---|--|
|      |  | Form  | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species  |  |   |  |
| 51   | Shelly silty sandy gravel.<br><br>Old mussel patch with <i>Sabellaria</i> tubes and crusts.<br><br>Mussel patch consisting of large, old individuals (absolute percentage 26%). Hard to assess if alive or dead, the majority appear to be dead. | Moribund loose tubes and Crusts on dead mussel shell and sediment (3% cover).<br><br>No reef. | *              | *               | *                         | Hydrozoan / Bryozoan turf, <i>Flustra foliacea</i> , <i>Pomatoceros</i> sp.                |   | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |
| 52   | Shelly, silty sandy gravel.  | Absent  | *              | *               | *                         | Bryozoan crust, <i>Ophiura albida</i> , <i>Pomatoceros</i> sp., Hydrozoan / Bryozoan turf. |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

| Site | Sediment and <i>Mytilus edulis</i> / <i>Ampelisca diadema</i> aggregation description  | Sabellaria characteristics  |                |                 |                           |   | Image   | Sabellaria reef definition based on Elevation | Sabellaria reef definition based on Patchiness |
|------|--|---|----------------|-----------------|---------------------------|---|---|---|--|
|      |  | Form  | Reef Elevation | Reef Patchiness | Brief description of reef | Other conspicuous species   |   |   |  |
| 53   | Shelly silty sand with gravel in some areas.<br><br>Seed mussel bed consisting of small, live individuals. Absolute percentage of mussels - 45%. | Moribund loose tubes, Crusts and Clumps (2% cover).<br><br>No reef. | *              | *               | *                         | <i>Flustra foliacea</i> ,<br>Hydrozoan / Bryozoan turf, <i>Pomatoceros</i> sp.,<br><i>Liocarcinus</i> sp., <i>Ophiura</i> sp., <i>Sabella</i> sp.,<br>Anthozoa indet,<br><i>Buccinum undatum</i> ,<br>Bryozoan crust, <i>Ophiura albida</i> . |  | NOT SABELLARIA REEF                           | NOT SABELLARIA REEF                            |

### *Presence of Sabellaria spinulosa Aggregations*

To allocate the scoring system to the *Sabellaria spinulosa* formations present, a 3-stage analysis approach (based on Hendrick & Foster-Smith, 2006 and JNCC, 2007) was applied. Of the 38 sites surveyed using drop down video, 4 sites contained possible *Sabellaria* reef. – Sites 16, 42, 44 and 49. These sites were classified as reef as they displayed scores for both elevation and patchiness based on JNCC (2007).

It is important to note that the elevation scores for the reef areas were uniformly low, with tube height ranging from 2-4cm. For this reason the *Sabellaria* reef contained within the survey area would be described as borderline low-lying reef. Three out of the 4 sites containing potential *Sabellaria* reef were also allocated a low score for patchiness. The low-lying nature of the reef made distinguishing between reef and crust during the video analyses difficult.

Results from the grabbing survey solely indicated clumps of *Sabellaria* at the 4 sites later classified as low lying reef though video and image analysis. This may be due to the grab itself breaking up *Sabellaria* aggregations through its ‘scooping’ sampling action, resulting in <10cm diameter clumps rather than the larger aggregations observed in the video footage which were classified as potential reef.

Static video and sidescan images of a representative low-lying reef site are presented in Table 3.5.3. Drawing J.1.02.1495.04 illustrates the location of the low-lying *Sabellaria* reef and their estimated extent based on geophysical and hydrographic interpretation.

One of the *Sabellaria* reef sites, located in the east, was classified as a ‘seed mussel and *Sabellaria* reef feature’ as it co-occurred with a seed mussel bed. The other three reef sites were classified as ‘low-lying *Sabellaria* reef’ and were located in the north-west of the survey array and western most edge of one of the export cables to shore.

The areas of *Sabellaria* reef occurred within silty sandy gravel, gravely silty sand and mobile sand areas. This concurs with previous studies that found the boundary between sand and sandy/gravels was a typical habitat for *Sabellaria* (Foster-Smith & Hendrick, 2003).

Results of the drop down video and grab survey indicated that *Sabellaria* aggregations, consisting of tubes, crusts and occasional clumps, were found throughout the area surveyed. These aggregations were found associated with a variety of substrate types within the survey array including:

- Old mussel patches to the west;
- Mobile sand areas in the south east and western most points of the export cables;
- Many of the gravelly silty sand substrates in the north-west, west and south;
- Silty sandy gravel areas in the centre of the array and to the south-east and west.

The distribution of these *Sabellaria* aggregations is highlighted within Drawing J.1.02.1495.04.

**Table 3.5.3 Example of an area of possible low lying reef from both sidescan sonar and video imagery**

| Site | Sidescan Image  | Static Video Image   | Elevation | Patchiness |
|------|---|--|-----------|------------|
| 44   |  |  | LOW       | HIGH       |

***Sabellaria* Aggregations along Inter-Array Cables on the Lynn Wind Farm site**

No *Sabellaria* reef was found along the inter-array cable runs within the Lynn array (see Figure 1.4.2 for location of these cables, corresponding with ground truth Sites 24, 25, 51, 52, 53). However, *Sabellaria* agglomerations in the form of tubes, crusts and clumps were found associated with areas of old mussel patches, gravelly silty sand and seed mussel beds.

Site 53 was found to contain a seed mussel bed. Whether or not this feature can be classified as a biogenic reef and therefore if it is afforded any statutory protection is discussed later in this section under ‘*Presence of Mytilus edulis* beds and *Ampelisca diadema* reef’.

**Laboratory Faunal Analysis of *Sabellaria* Aggregation**

To gain further information on the form of *Sabellaria* aggregations and the composition of their associated faunal communities, a grab sample was taken from Site 43 for analysis at Emu’s laboratories.

The grab sample collected at Site 43 contained clumps of *Sabellaria*, similar to those found at the four sites later classified as potential low lying *Sabellaria* reef. Further investigation of *Sabellaria* aggregations at Site 43 through video and stills analyses revealed abundant crusts (25% cover) but no elevation was apparent. As the site contained relatively dense aggregations of *Sabellaria* crust and some clumps, it supported a typical rich *Sabellaria* community.

Appendix I contains a full species list for Site 43. A total of 41 taxa were found, with over 300 live individuals of *Sabellaria spinulosa* recorded. The associated faunal community encompassed: amphipods, primarily *Ampelisca diadema*, with almost 250 individuals recorded; a diverse range of polychaetes, including *Protodorvillea kefersteini*, *Lumbrineris gracilis* and *Eunereis longissima*; crabs such as *Pisidia longicornis*; a number of bivalves, including *Nucula nucleus*, brittlestars; hydroids; bryozoans; anemones and sea squirts.

The two clumps of *Sabellaria* contained in the grab at Site 43 were poorly consolidated and approximately 3cm in diameter. Tube heights ranged from 2 to 4cm - see Figure 3.5.1 below. The diverse associated faunal community found at Site 43 and the elevation of *Sabellaria* tubes contained in the grab sample indicate that the potential for low lying reef occurring in the area cannot be ruled out. As has been noted previously, distinguishing between crust and reef in the video analysis was difficult due to the apparent low lying nature of the reef

observed in the survey area. As such, it is suggested that Site 43 is probably on the boundary of *Sabellaria* reefs, possibly those identified to the south (Site 44) and to the east (Site 42).

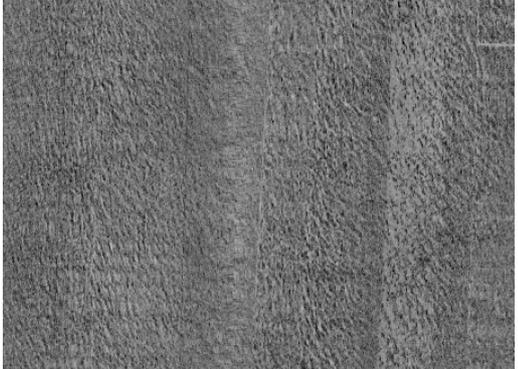


**Figure 3.5.1** Example of *Sabellaria* aggregations from Site 43. A scale is given to assess tube height.

***Presence of Mytilus edulis beds and Ampelisca diadema reef***

Two types of Blue mussel, *Mytilus edulis*, aggregations were found within the survey area. The first consisted of dense aggregations of live seed mussels and were defined as ‘seed mussel beds’. Static video and sidescan images of a representative seed mussel bed site are presented in Table 3.5.4.

**Table 3.5.4** Example of an area of seed mussel bed from both sidescan sonar and video imagery

| Site | Sidescan Image  | Static Video Image   |
|------|---|--|
| 53   |  |  |

Two seed mussel beds with *Sabellaria* aggregations in tube, crust and clump form were observed (Sites 35 & 53) and a seed mussel and *Sabellaria* reef feature (Site 49). The latter feature and one of the seed mussel beds occurred in close proximity, at the eastern edge of the

survey array. The other bed was observed to the south west of the survey area. The substrate within both areas consisted of silty sand.

As discussed within Section 1.3, seed mussel beds would not normally be regarded as biogenic reefs which tend to be more permanent features (Prof Ray Seed, pers comm. 03/12/09 & 07/12/09). However, based on observations by Suchanek (1979) outlined in a paper by Holt *et al.* (1998) it could be argued that the seed mussel beds found in the current survey fulfil most of the criteria of a biogenic reef. Suchanek (1979) described *Mytilus* beds in terms of 3 structural components;

- i) a physical matrix of living and dead shells;
- ii) a bottom layer of accumulated sediments, mussel faeces and pseudofaeces, organic detritus and shell debris;
- iii) an assemblage of associated flora and fauna.

The first and the last criteria appear to be fulfilled at the seed mussel sites observed in the current survey but, it is difficult to assess if there is a layer of accumulated faeces/organic detritus as this was not explicitly sampled. To assess if these seed mussel beds qualify as Annex 1 *Mytilus* reef further investigation at these sites is required.

The second consisted of patchy assemblages of predominantly dead large mussel shells. These aggregations were classified as 'old mussel patches'. It was extremely difficult to assign a percentage for live and dead individuals in these areas due to the level of sediment cover and the layers of shell present. Although many of the shells were clearly dead some individuals did appear to be alive. The presence of *Asterias rubens* in these areas, apparently feeding on the bivalves, supports this conclusion.

Although the old mussel patches consisted primarily of dead shell they were deemed an important feature to map due to their prominence in the area and the co-occurrence of *Sabellaria* aggregations within many of the patches. This feature covered large areas along the western edge of the array and was also found midway along the export cables to shore. The substrate type associated with these patches consisted of silty sandy gravel/gravelly silty sand or muddy sand substrates. Drawing J.1.02.1495.04 illustrates the location of the seed mussel beds and old mussel patches.

Two sites, 14 and 18, contained dense *Ampelisca* aggregations which formed a continuous feature. These were defined as *Ampelisca* reef and were plotted on Drawing J.1.02.1495.04 as a feature of interest.

One of the areas of *Ampelisca* reef was found along the export cable at the south of the array, and the other at the south western edge of the array. Both occurred within areas of gravelly silty sand.

#### ***Laboratory Faunal Analysis of Ampelisca Aggregation***

To ensure correct identification of the species of *Ampelisca* found in the study area, and to provide a representative sample of the species associated with the reef, a grab sample was taken from Site 14 and sent back to Emu Ltd's laboratory for further analyses. Appendix J contains a full species list for Site 14.

The laboratory analysis confirmed that the *Ampelisca* species found in this survey was *Ampelisca diadema*, with over 900 live individuals of this species enumerated in the sample.

A total of 63 taxa were found associated with the *Ampelisca* reef. The associated faunal community encompassed: other amphipod species, including *Corophium bonellii*; a diverse polychaete community, including *Pholoe baltica* and *Eunereis longissima*; crabs such as *Pisidia longicornis*; bivalves, including *Nucula nucleus* and *Abra alba*; hydroids; anemones and bryozoans.

### ***Defining the Extent of Likely Biogenic Reef***

Prior to commencing the ecological assessment survey, areas of different texture and reflectivity in the initial sidescan sonar results were delineated as features on the mosaiced data to ground truth in the video and grab survey. After the ground truthing had been analysed it was decided to further refine the final sidescan sonar interpretation to identify the seabed characteristics in individual lines of data, based on these ecological findings. This form of analysis provided greater detail and definition of the boundaries, features and seabed types.

The *Sabellaria* reef, seed mussel bed and old mussel patch features found in the video and grab survey, were not associated with a unique signature on the sidescan sonar or bathymetry. The many patchy formations observed from geophysical data did indicate a high probability of biogenic features being present but distinctions between these features could not be made utilising the geophysical and hydrographic interpretation alone. Only where there was a ground truth site within an area delineated by geophysical data was a region classified as a particular feature.

It was found to be highly probable that the formations that predominate in the western regions of the site were old mussel patches. Low lying *Sabellaria* reef was identified at two areas in the north west of the array and at the western end of the northern cable route. The seed mussel and *Sabellaria* reef feature was patchily distributed within an area in the east of the array. Seed mussel beds were identified in the east of the array and in one site in the south west of the survey area.

Where delineated areas of high contrast reflectivity with increased surface roughness did not contain a ground truth site, the specific feature the area encompassed could not be determined. Such areas could only be classified as 'likely areas of *Sabellaria* reef, seed mussel or old mussel patches'. Drawing J.1.02.1495.04 illustrates the geophysical and hydrographic delineations of features.

## 4 CONCLUSIONS

### *Geophysical component*

The survey was performed to the highest standards using the best equipment and experienced personnel. The survey data acquired offshore were of good quality and in all cases deemed to satisfy the requirements of the contract. Data collection and processing was conducted with great care and in accordance with Emu Limited's quality management system which complies with requirements of BS EN ISO 9001:2008.

The use of multibeam acoustic backscatter to determine acoustic variability is a relatively new technique for classifying seabed features. The data did provide information that tied in with observations in the bathymetry and sidescan sonar. However, it did not classify areas of the seabed as being of any specific biogenic feature. This was partly to do with the low acoustic variability across the site (as also observed in the sidescan data) and also the fact the low lying reef identified from the ecological ground truthing survey was not well defined.

### *Ecological component*

The current study found *Sabellaria* aggregations in the form of tubes, crusts and clumps throughout the survey area, which supports the findings from a previous baseline study of the area by Envision Mapping Ltd (Sotheran *et al.*, 2005). The aforementioned study did not identify any areas of low lying reef due possibly to the utilisation of different classification procedures for 'reefiness' than those adopted here.

In addition, the survey by Envision Mapping Ltd did not identify any areas of seed mussel beds in contrast to both the findings from the current study and an earlier survey conducted by The Eastern Sea Fisheries Joint Committee in 2008 (ESFJC, 2008).

When combining the hydrographic and ecological data, results show that potential low lying *Sabellaria* reef was located in four main areas within the Lynn and Inner Dowsing wind farm and export cable area. One of the areas also included seed mussel beds, a feature that was found in two further areas within the survey site.

In its reef form, *Sabellaria spinulosa* is listed as a biogenic reef under Annex I of the EC Habitats Directive (Council Directive EEC/92/43 on the Conservation of Natural Habitats and of Wild Fauna and Flora). In addition, *Sabellaria spinulosa* reef is also included on the UK list of Priority Habitats for conservation action under the UK Biodiversity Action Plan (Maddock, 2008).

As part of Emu's Quality Assurance procedures and in the interests of our ongoing development, every contract undergoes a comprehensive review on completion. This process is designed to identify any areas where improvements can be made.

## 5 HEALTH & SAFETY

Prior to survey commencement all survey personnel and crew completed a CREL health and safety questionnaire

On the commencement of the survey a safety briefing was attended by all survey personnel whereupon the emergency procedures were explained and emergency equipment demonstrated.

A safety plan and risk assessment was completed prior to survey commencement and can be viewed on request. All survey and crew members were required to read and sign the safety plan.

No incidents occurred during this contract.

---

**6 REFERENCES**

**Emu Limited (2005).** Geophysical Survey for Proposed Lincs Offshore Wind Farm. Emu Report No. J/1/02/0744.

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**Emu Limited (2008).** Acoustic Surveys for the Proposed Lincs Offshore Wind Farm Sites. Emu Report No. 08/J/1/02/1166/0779

**Foster-Smith, R.L. and Hendrick, V.J., (2003).** *Sabellaria spinulosa* reef in The Wash and North Norfolk cSAC and its approaches: Part III, Summary of Knowledge, recommended monitoring strategies and outstanding research requirements. English Nature Research Reports: Number 543. Report produced by Envision Mapping on behalf of the Eastern Sea Fisheries Joint Committee and English Nature. March 2003.

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**Holt, T.J., Rees, I.E., Hawkins, S.J. and Seed, R. (1998).** Biogenic Reefs (volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science (UK Marine SACs Project). 170 pages.

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**Mackenzie, C.L.Jr., Pilanowski, R., McMillan, D.G. (2006).** *Ampelisca* amphipod tube mats may enhance abundance of northern quahogs *Mercenaria mercenaria* in muddy sediments. *Journal of Shellfisheries Research*.

**Maddock, A. 2008.** UK Biodiversity Action Plan; Priority Habitat Descriptions. Brig.

**Oceanix International Limited (2009).** *FPV Morven* Vessel Offsets Survey Report

**Sotheran, I.S., Foster-Smith, R.L., Hendrick, V.J. and Foster-Smith, D.J. (2005).** *Sabellaria spinulosa* survey. Lynn, Lincs and Inner Dowing Offshore Windfarms. Envision Mapping Ltd., Newcastle Upon Tyne, UK

**The Eastern Sea Fisheries Joint Committee (ESFJC) (2008).** Information collected by The Eastern Sea Fisheries Joint Committee in July 2008, supplied by Gero Vella, RES Ltd., to Emu Ltd.

**Websites:**

**URL – Joint Nature Conservation Council (2009)**

[http://www.jncc.gov.uk/protected sites/SACselection/habitat.asp?featureIntcode=H1170](http://www.jncc.gov.uk/protected%20sites/SACselection/habitat.asp?featureIntcode=H1170)

Protected sites information

Visited 07-10-09

**URL– Massachusetts Water Resources Authority.**

[http://www.mwra.state.ma.us/harbor/pdf/diaz\\_20080610.pdf](http://www.mwra.state.ma.us/harbor/pdf/diaz_20080610.pdf)

Diaz, R.J (2007). Assessment of Boston Harbor Sediment Habitat Quality: Changes Over Time. Power point presentation.

Visited 08-10-09

**Emu Ltd Quality Assurance Documents:**

EMU MET 05 : Infaunal and Epifaunal Sampling Methods and Procedures, Issue 2 – January 2004

EMU MET 06 : Benthic Sediment Sampling and Processing Methods and Procedures, Issue 1 – August 1998

EMU MET 07 : Methods for the Processing, Identification, Enumeration and Recording of Marine Benthic Macro-invertebrates, Issue 5 – May 2006

**APPENDIX A**  
**Service Constraints**

## **Service Constraints**

This report and the data were compiled and carried out by Emu Limited (Emu), in accordance with Emu's proposal document number P/1/02/09/0833, "Lynn and Inner Dowsing Hydrographic Monitoring Survey – A Proposal to RES". The services were performed by Emu with the skill and care ordinarily exercised by a reasonable hydrographic survey specialist at the time the services were performed. Further, and in particular, the services were performed by Emu taking into account the limits of the scope of works required by the Client, the time scale involved and the resources, including financial and manpower resources, agreed between Emu and the Client.

Other than that expressly contained in paragraph 1 above Emu provides no other representation or warranty whether express or implied, in relation to the services.

The services were performed by Emu exclusively for the purposes of the client. Emu is not aware of any interest of or reliance by any party other than the client in or on the services. Unless expressly provided in writing, Emu does not authorise, consent or condone any party other than the client relying upon the services. Should this report or any part of this report, or otherwise, details of the services or any part of the services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and Emu disclaims any liability to such party. Any such party would be well advised to seek independent advice from a competent hydrographic survey specialist and / or lawyer.

It is Emu's understanding that this report is to be used for the purpose described in Section 1.1 of this report. That purpose was a significant factor in determining the scope and level of the services. Should the purpose for which the report is used, and / or should the clients proposed development or use of the site change (including in particular any change in any design and / or specification relating to the proposed use or development of the site), this report may no longer be valid or appropriate and any further use of or reliance upon the report in those circumstances by the Client without Emu's review and advice shall be at the clients sole and own risk. Should Emu be requested, and Emu agree, to review the report after the date hereof, Emu shall be entitled to additional payment at the then existing rates or such other terms as may be agreed between Emu and the client.

The passage of time may result in changes (whether man-made or otherwise) in site conditions and changes in regulatory or other legal provisions, technology, methods of analysis, or economic conditions which could render the report inaccurate or unreliable. The information, recommendations and conclusions contained in this report should not be relied upon if any such changes have occurred or after the period of 2 years from the date of this report or such other period as may be expressly stated in the report, without the written agreement of Emu. In the absence of such written agreement of Emu, reliance on the report after any such changes have occurred or after the period of 2 years has expired, shall be at the clients own sole risk. Should Emu agree to review the report after the period of 2 years has expired, Emu shall be entitled to additional payment at the existing rates or such other terms as maybe agreed between Emu and the Client.

The observations, recommendations and conclusions in this report are based solely upon the services which were provided pursuant to the contract between the client and Emu. Emu has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and Emu. Emu is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the services.

Where the services have involved Emu's interpretation and / or other use of any information (including documentation or materials, analysis, recommendations and conclusions) provided by third parties (including independent testing and / or information services / laboratories) or the client and upon which Emu was reasonably entitled to rely or involved Emu's observations of existing physical conditions of any site involved in the services, then the services clearly are limited by the accuracy of such information and the observations which were reasonably possible of the said site. Unless otherwise stated, Emu was not authorised and did not attempt to independently verify the accuracy or completeness of such information, received from the client or third parties during the performance of the services. Emu is not liable for any inaccuracies (including any incompleteness) in the said information, the discovery of which inaccuracies required the doing of any act including the gathering of any information which it was not reasonably possible for Emu to do including the doing of any independent investigation of the information provided to Emu save as otherwise provided in the term's of the contract between client and Emu.

**APPENDIX B**  
**Daily Logs & DPRs**

**APPENDIX C**  
**Tidal Curves**

**APPENDIX D**  
**Sound Velocity Profiles**

**APPENDIX E**  
**Turbine Scour**

**APPENDIX F**  
**Sidescan Sonar Contact Report**

**APPENDIX G**  
**Hyperdigital Camera Logs**

**APPENDIX H**  
**Grab Log and Inventory**

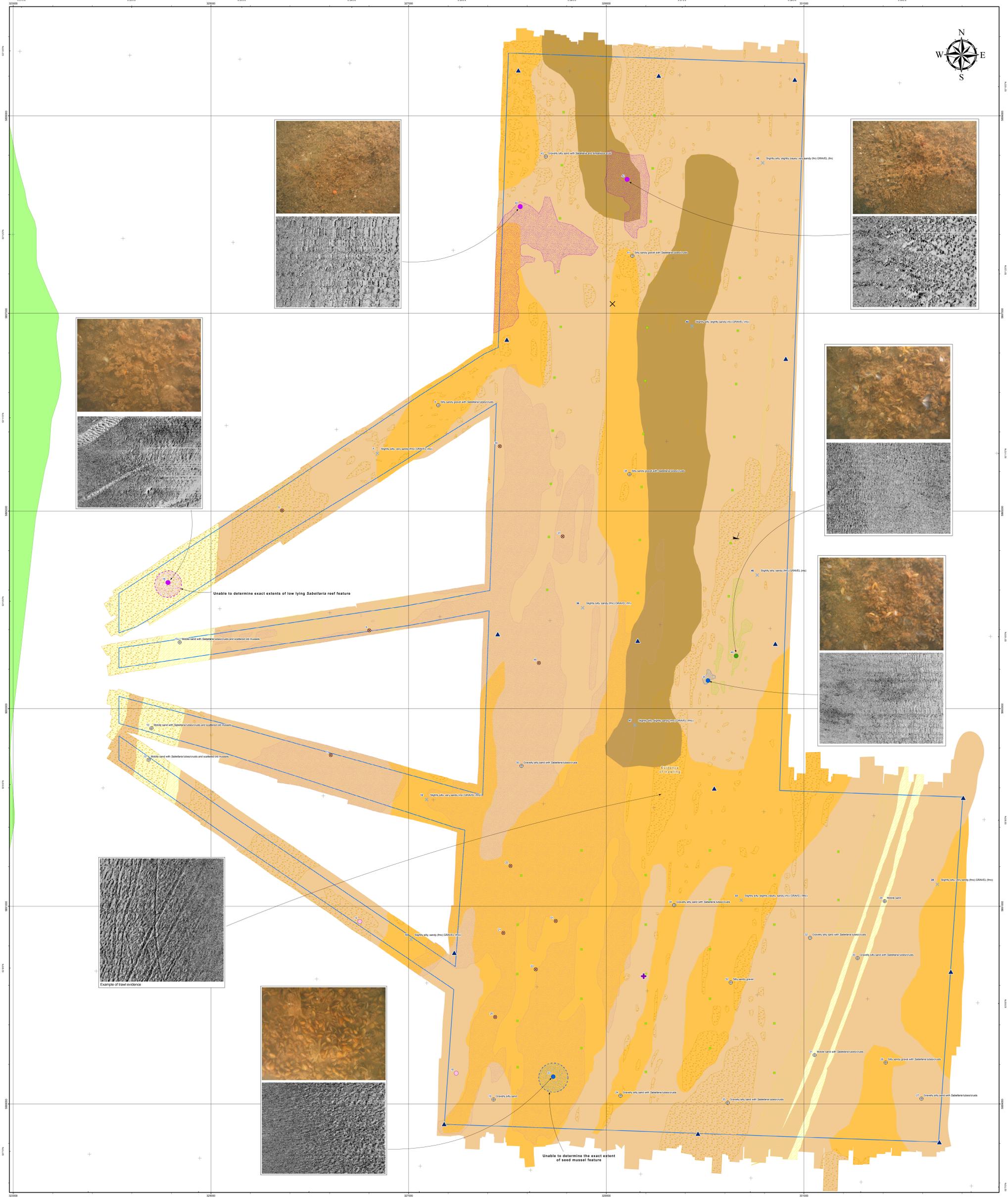
**APPENDIX I**  
**Video and Stills Data Review**

**APPENDIX J**  
**Species List – *Sabellaria* and *Ampelisca* site examples**

**APPENDIX K**  
**Survey Equipment**

**APPENDIX L**  
**Vessel Safety Inspection Report**

**APPENDIX M**  
**Drawings**



**Legend**

**Survey Area**

- Turbines
- Grab Samples (f = fine, m = medium, c = coarse)

**Groundtruth Description**

- Low lying Sabellaria Reef
- Seed mussel and Sabellaria reef feature
- Seed mussel bed with Sabellaria tubestrucula/dumps
- Amphipods reef
- Old Mussel patch
- Not reef

**Groundtruth Features Interpretation**

- High probability of low lying Sabellaria reef
- High probability of old mussel patch
- High probability of seed mussel and Sabellaria reef
- High probability of seed mussel bed with Sabellaria tubestrucula/dumps
- Irregular patches of high contrast reflectivity with increased surface roughness
- Not possible to distinguish between Sabellaria reef, seed mussel bed or old mussel patch

**Seabed Sediment Interpretation**

- Sandwaves
- GRAVEL
- Sandy coarse GRAVEL
- Sandy GRAVEL
- Gravelly SAND

**Hydrographic Features**

- Lighthouse
- Mast (Approx. 2 m diameter)

**Charted Obstructions**  
(No evidence based on survey data collected)

- Obstruction
- Wreck

**Notes**

**Coordinate System:** WGS84 UTM Zone 31 North

**Vertical Datum:** All depths have been reduced to Chart Datum at Skegness (3.75 m below Ordnance Datum Newlyn)

**Depth:** All depths are in metres below Chart Datum

**Vessel:** FPV Moven

**Date Surveyed:** 30th June to 26th July 2009

**Surveyors:** JHC / SLD / DCS / ACH / AGR

**Charted Obstructions:** Captured from admiralty chart 108, edition date 30/10/2008

**Geophysical, Hydrographic and Ecological Seabed Interpretation**

- Text sediment descriptions on plot from ecological field and video observation only
- Seabed sediment interpretation utilised Envison PSA data from 2005 and field descriptions from Emu 2009 survey

| Rev. | Date     | Description         | Initials |
|------|----------|---------------------|----------|
| 0    | 09/10/09 | Draft Issue         | MXP      |
| 1    | 23/10/09 | Revised Draft Issue | MXP      |
| 2    | 14/12/09 | Final Issue         | MXP      |

**Equipment**

**Positioning System:** Primary - Applanix POS MV with differential corrections from Hemisphere Cresscor R120 dGPS; Secondary - Hemisphere Cresscor R120 dGPS

**Navigation Data Acquisition System:** QPS QINSY version 6

**Motion Reference Unit:** Applanix Pos MV

**Vertical Heights:** Leica 1200 PPK GPS

**Multibeam Echosounder:** Reson Seabat 8101 240kHz head

**Sound Velocity Probe:** QPS QINSY version 6

**Sidescan Sonar System:** Klein 3000

**Sidescan Acquisition System:** SonarPro

**Sidescan Processing Software:** SonarWiz version 4

**Sound Velocity Probe:** Valeport miniVSP

**Underwater Video System:** Kongsberg OE14-208 SM Pixel Digital stills camera housed within Extreme Low Visibility System

**Grab type:** 0.1m<sup>3</sup> mini-Hamom

**FPV Moven Vessel Offset Diagram:**

**Survey Location**

**Scale**

0 500 1,000 Metres

0 0.5 1 Nautical Miles

**Client**

**centrica energy**

Centrica Renewable Energy Limited  
Millstream East  
Maldenhead Road  
Widnes  
SL4 6SD

**Survey Contractor**

**EMU**

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1st Court  
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Website: www.emulimited.com

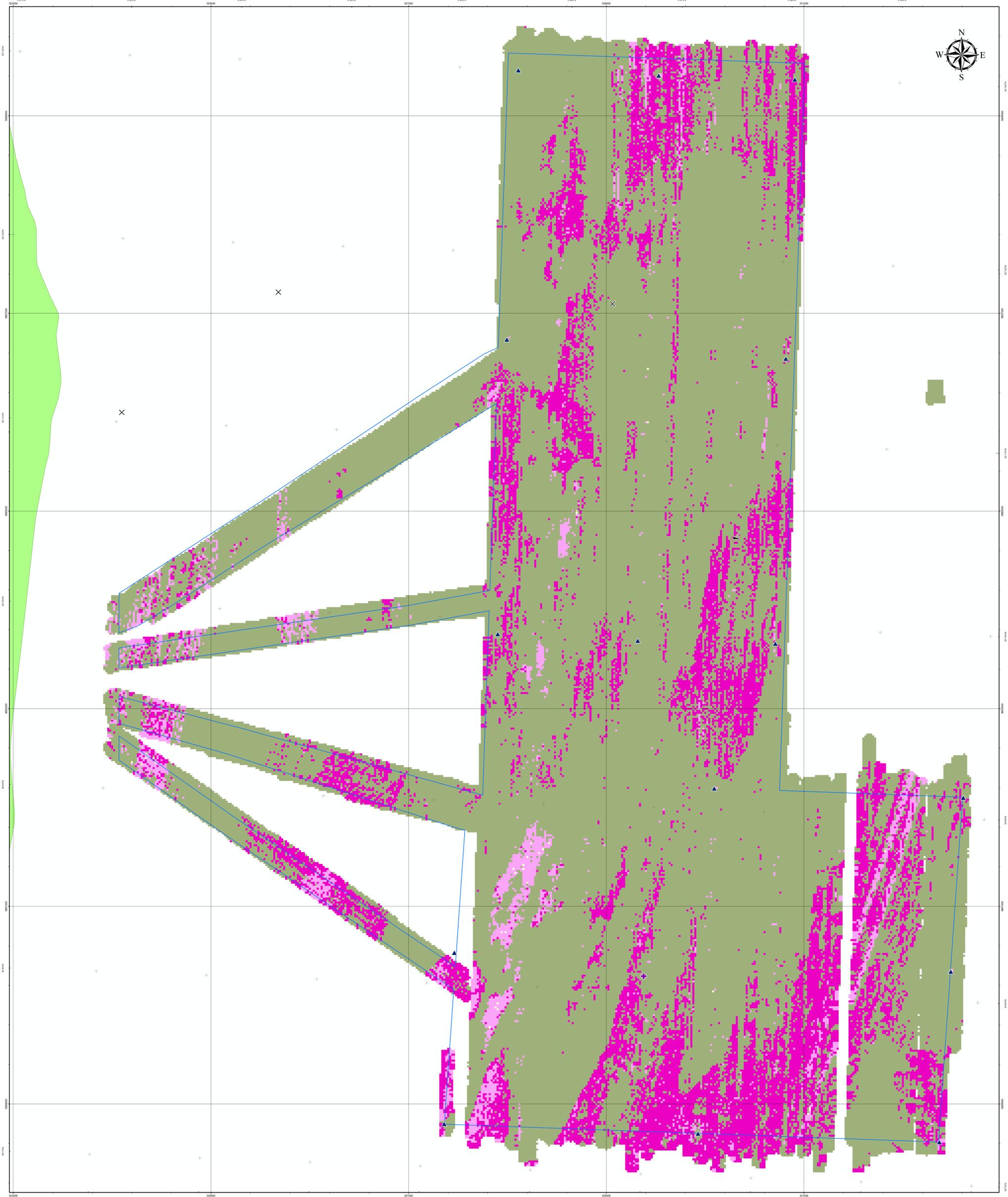
**Project Title**

**Lynn and Inner Dowsing Hydrographic Monitoring Survey**

**Drawing Title**

**Geophysical, Hydrographic and Ecological Seabed Interpretation**

|             |                |             |            |
|-------------|----------------|-------------|------------|
| Job No.     | J/1/02/1495    | Date Issued | 14/12/2009 |
| Drawn by    | MXP            | Sheet Size  | ISO A0     |
| Approved by |                | Scale       | 1:12500    |
| Drawing No. | J.1.02.1495.04 | Rev.        | 2          |



**Legend**

**Hydrographic Features**

- Lightbuoy
- Mast (Approx. 2 m diameter)

**Charted Obstructions** (No evidence based on survey data collected)

- Obstruction
- Wreck

**Backscatter Classification**

- Class 2 - Sandy GRAVEL
- Class 3 - GRAVEL and sandy coarse GRAVEL
- Class 5 - Gravelly SAND and high density of old mussel patches

**Notes**

Coordinate System: WGS84 UTM Zone 31 North  
 Vertical Datum: All depths have been reduced to Chart Datum at Skagness (3.75 m below Ordnance Datum Newlyn)  
 Depths: All depths are in metres below Chart Datum  
 Vessel: FPV Moven  
 Date Surveyed: 30th June to 28th July 2009  
 Surveyors: JHC / SJD / DCS / ACH / AGR  
 Charted Obstructions: Captured from admiralty chart 108, edition date 30/10/2008

| Rev. | Date     | Description | Initials |
|------|----------|-------------|----------|
| 0    | 23/10/09 | Draft Issue | IMR      |
| 1    | 14/12/09 | Final Issue | IMR      |

**Equipment**

Positioning System: Primary - Applanix POS MV with differential corrections from Hemisphere Crescent R120 dGPS  
 Secondary - Hemisphere Crescent R120 dGPS  
 Navigation Data Acquisition System: QPS QINSy version 6  
 Motion Reference Unit: Applanix Pos MV  
 Vertical Heights: Leica 1200 PPK GPS  
 Multibeam Echo-sounder: Reson Seabat 8101 240kHz head  
 Multibeam Processing Software: QPS QINSy version 6  
 Sidescan Sonar System: Klein 3000  
 Sidescan Acquisition System: SonarPro  
 Sidescan Processing Software: SonarWiz version 4  
 Sound Velocity Probe: Valeport msvDP  
 FPV Moven Vessel Offset Diagram:

**Survey Location**

**Scale**

**Client**

**centrica energy**

Centrica Renewable Energy Limited  
 Millstream East  
 Maidenhead Road  
 Windsor  
 SL4 6SD

**Survey Contractor**

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 E-mail: mail@emulimited.com  
 Website: www.emulimited.com

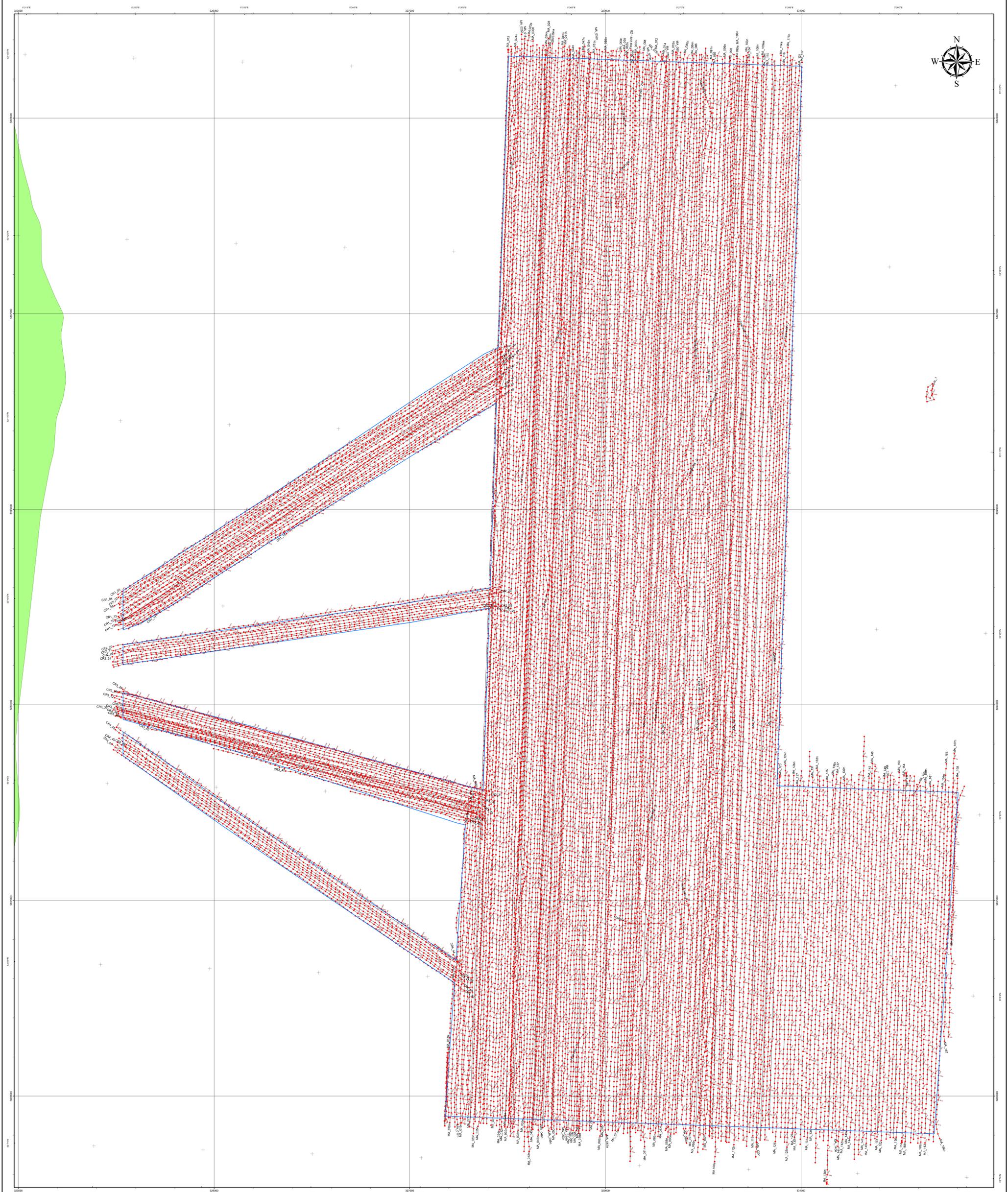
**Project Title**

**Lynn and Inner Dowsing  
 Hydrographic Monitoring Survey**

**Drawing Title**

**Multibeam Acoustic Backscatter  
 Interpretation**

|             |                |             |            |
|-------------|----------------|-------------|------------|
| Job No.     | J/1/02/1495    | Date Issued | 14/12/2009 |
| Drawn by    | IMR            | Sheet Size  | ISO A0     |
| Approved by |                | Scale       | 1:12500    |
| Drawing No. | J.1.02.1495.05 | Rev.        | 1          |



**Legend**

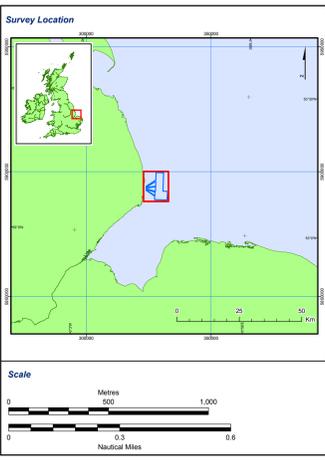
- Survey Area
- Fix Point (50 m interval)
- Trackline

**Notes**

Coordinate System: WGS84 UTM Zone 31 North  
 Vertical Datum: All depths have been reduced to Chart Datum at Skagness (0.75 m below Ordnance Datum Newlyn)  
 Depths: All depths are in metres below Chart Datum  
 Vessel: FPV Moven  
 Date Surveyed: 30th June to 26th July 2009  
 Surveyors: JHC / SLD / DCS / ACH / AGR

**Equipment**

Positioning System: Primary - Applanix POS MV with differential corrections from Hemisphere Crescent R120 dGPS  
 Secondary - Hemisphere Crescent R120 dGPS  
 Navigation Data Acquisition System: GPS QINSY version 6  
 Motion Reference Unit: Applanix Pos MV  
 Vertical Heights: Leica 1200 PPK GPS  
 Multibeam Echosounder: Reson Seabat 6101 340kHz head  
 Multibeam Processing Software: GPS QINSY version 6  
 Sidescan Sonar System: Klein 3000  
 Sidescan Acquisition System: SonarPro  
 Sidescan Processing Software: SonarWiz version 4  
 Sound Velocity Probe: Valeport msv5VP  
 FPV Moven Vessel Offset Diagram:



**Client**

**centrica energy**  
 Centrica Renewable Energy Limited  
 Millstream East  
 Main Road  
 Windsor  
 SL4 5GD

**Survey Contractor**

**EMU**  
 Emu Limited  
 1 Mill Court  
 The Saundries  
 Dursley  
 Southamption  
 Hampshire SO22 2EJ  
 Tel: +44 (0)1489 880050  
 Fax: +44 (0)1489 880059  
 E-mail: mail@emulimited.com  
 Website: www.emulimited.com

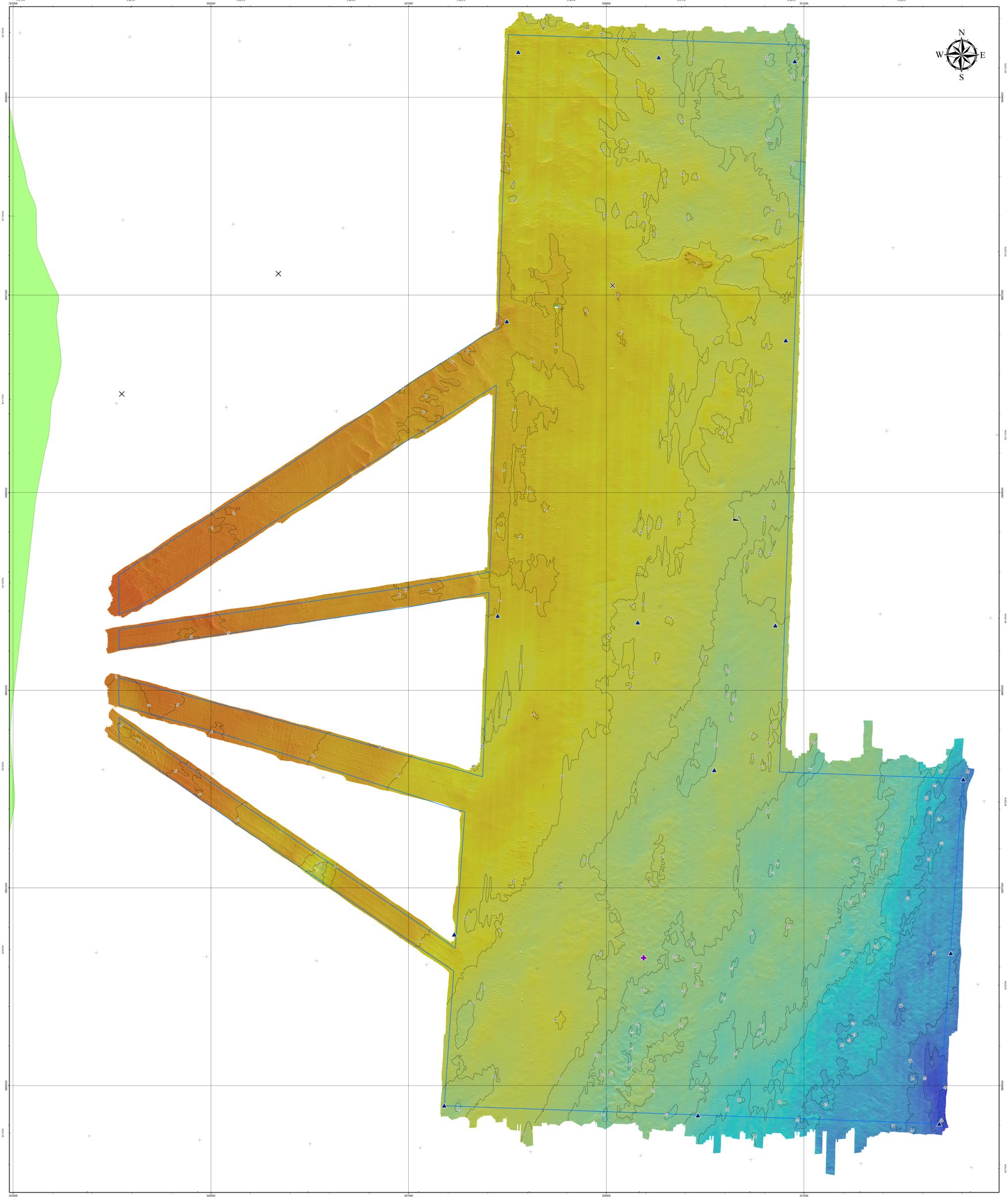
**Project Title**

**Lynn and Inner Dowsing Hydrographic Monitoring Survey**

**Drawing Title**

**Vessel Trackplot**

|             |                |             |            |
|-------------|----------------|-------------|------------|
| Job No.     | J/1/02/1495    | Date Issued | 14/12/2009 |
| Drawn by    | IMR            | Sheet Size  | ISO A0     |
| Approved by |                | Scale       | 1:12500    |
| Drawing No. | J.1.02.1495.01 | Rev.        | 1          |



**Legend**

**Hydrographic Features**

- Lightbuoy
- Mast (Approx. 2 m diameter)
- Charted Obstructions (No evidence based on survey data collected)
- Obstruction
- Wreck
- Contours

**Bathymetry (m below CD)**

**Notes**

Coordinate System: WGS84 UTM Zone 31 North  
 Vertical Datum: All depths have been reduced to Chart Datum at Skagness (3.75 m below Ordnance Datum Newlyn)  
 Depths: All depths are in metres below Chart Datum  
 Vessel: FPV Moven  
 Date Surveyed: 30th June to 26th July 2009  
 Surveyors: JHC / SLD / DCS / ACH / AGR  
 Charted Obstructions: Captured from admiralty chart 108, edition date 30/10/2008

| Rev. | Date     | Description | Initials |
|------|----------|-------------|----------|
| 0    | 23/10/09 | Draft Issue | IMR      |
| 1    | 14/12/09 | Final Issue | IMR      |

**Equipment**

Positioning System: Primary - Applanix POS MV with differential corrections from Hemisphere Crescenor R120 dGPS  
 Secondary - Hemisphere Crescenor R120 dGPS  
 Navigation Data Acquisition System: GPS QINSy version 6  
 Motion Reference Unit: Applanix Pos MV  
 Vertical Heights: Leica 1200 PPK GPS  
 Multibeam Echosounder: Reson Seabat 8101 240kHz head  
 Multibeam Processing Software: GPS QINSy version 6  
 Sidescan Sonar System: Klein 3000  
 Sidescan Acquisition System: SonarPro  
 Sidescan Processing Software: SonarWiz version 4  
 Sound Velocity Probe: Valeport miniSVIP  
 FPV Moven Vessel Offset Diagram:

**Survey Location**

**Scale**

**Client**

**centrica energy**  
 Centrica Renewable Energy Limited  
 Midstream East  
 Mablethorpe Road  
 Windsor  
 SL4 4 5ED

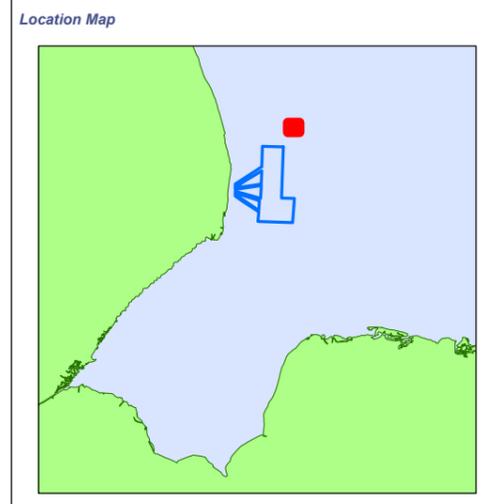
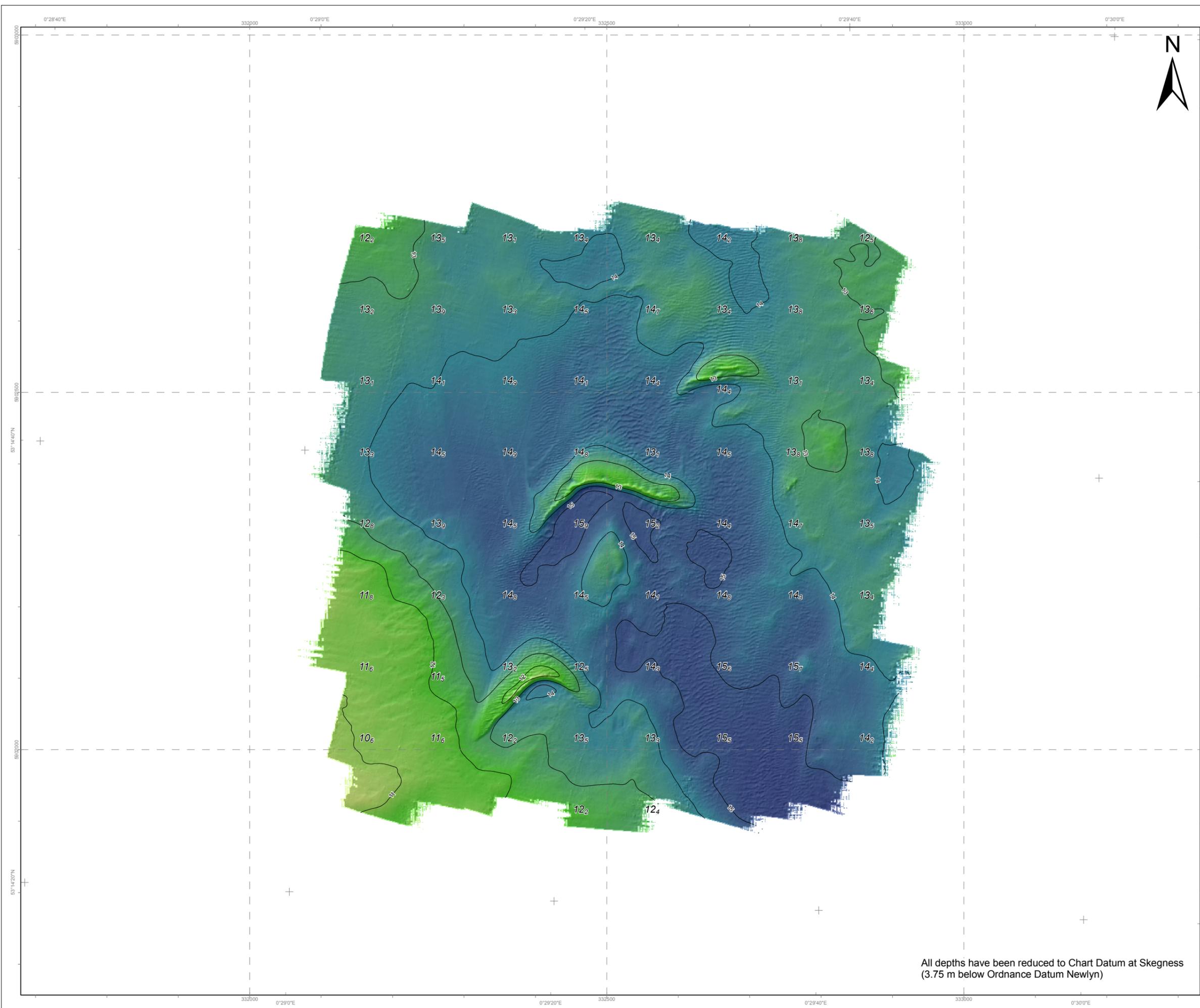
**Survey Contractor**

**EMU**  
 EMU Limited  
 1 Mill Court  
 The Swallows  
 Durney  
 Southampton  
 Hampshire SO32 2EL  
 Tel: +44 (0)1489 860050  
 Fax: +44 (0)1489 860051  
 E-mail: mail@emulimited.com  
 Website: www.emulimited.com

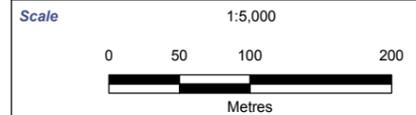
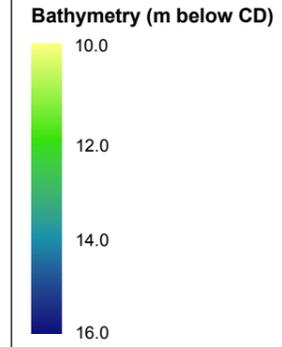
**Project Title**  
**Lynn and Inner Dowsing Hydrographic Monitoring Survey**

**Drawing Title**  
**Colour Shaded Bathymetry**

|             |                 |             |            |
|-------------|-----------------|-------------|------------|
| Job No.     | J/1/02/1495     | Date Issued | 14/12/2009 |
| Drawn by    | IMR             | Sheet Size  | ISO A0     |
| Approved by |                 | Scale       | 1:12500    |
| Drawing No. | J.1.02.1495.02a | Rev.        | 1          |



**Legend**  
 10<sub>s</sub> Depth Sounding (m)  
 — Contours



**Coordinate System**  
 WGS84 UTM Zone 31 North

**Survey Contractor**  
 Emu Limited  
 Ph: +44 (0) 1489 860050  
 Fax: +44 (0) 1489 860051  
 website: www.emulimited.com  
 email: mail@emulimited.com



**Client**  

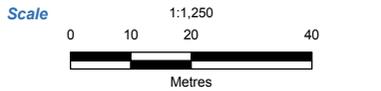
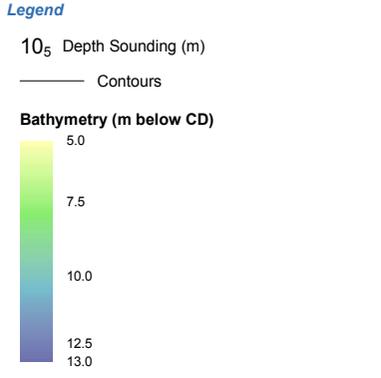
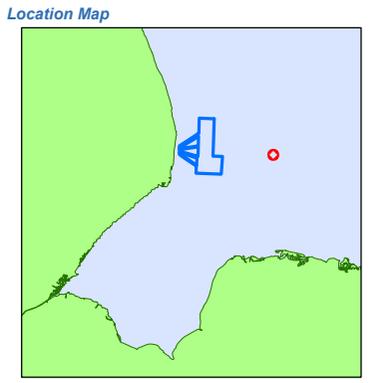
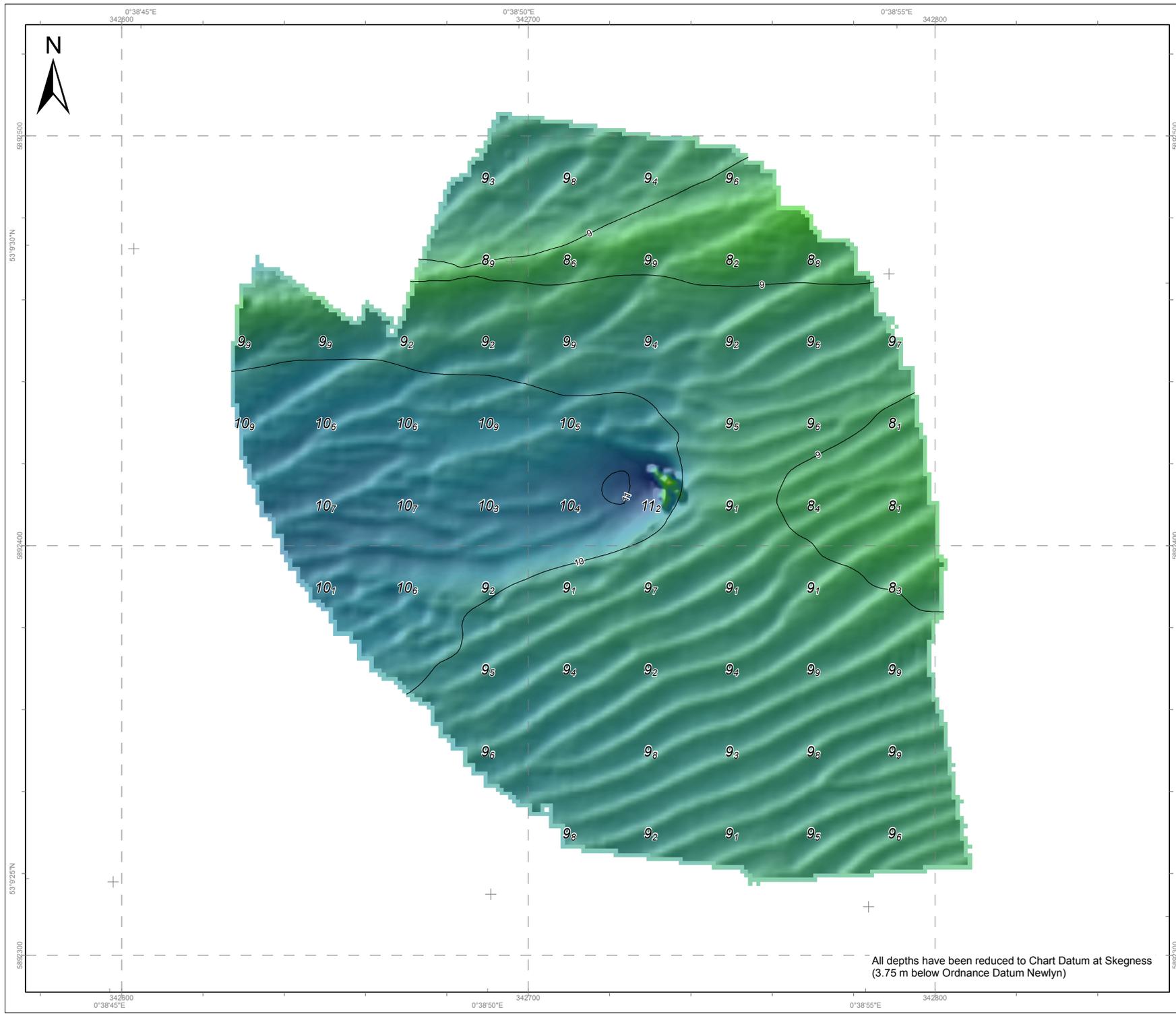

**Project Title**  
 Lynn and Inner Dowsing  
 Hydrographic Monitoring Survey

**Figure Title**  
 Colour Shaded Bathymetry  
 of the Sandwave Area

**J.1.02.1495.02b**

|                         |                               |                                   |                  |
|-------------------------|-------------------------------|-----------------------------------|------------------|
| <b>Drawn By:</b><br>IMR | <b>Issued On:</b><br>14/12/09 | <b>Job Number:</b><br>J/1/02/1495 | <b>Rev:</b><br>1 |
|-------------------------|-------------------------------|-----------------------------------|------------------|

All depths have been reduced to Chart Datum at Skegness  
 (3.75 m below Ordnance Datum Newlyn)



**Coordinate System**  
WGS84 UTM Zone 31 North

**Survey Contractor**  
Emu Limited  
Ph: +44 (0) 1489 860050  
Fax: +44 (0) 1489 860051  
website: www.emulimited.com  
email: mail@emulimited.com

**Client**

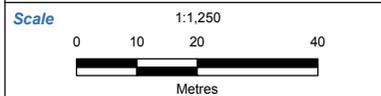
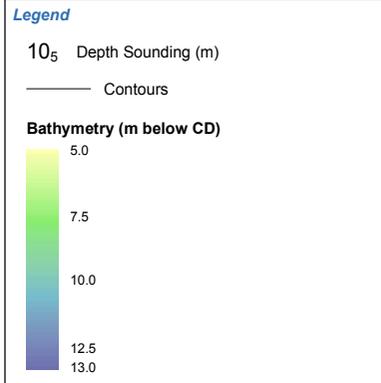
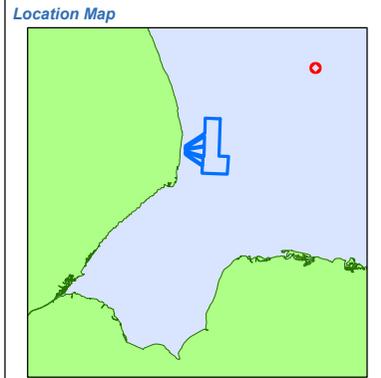
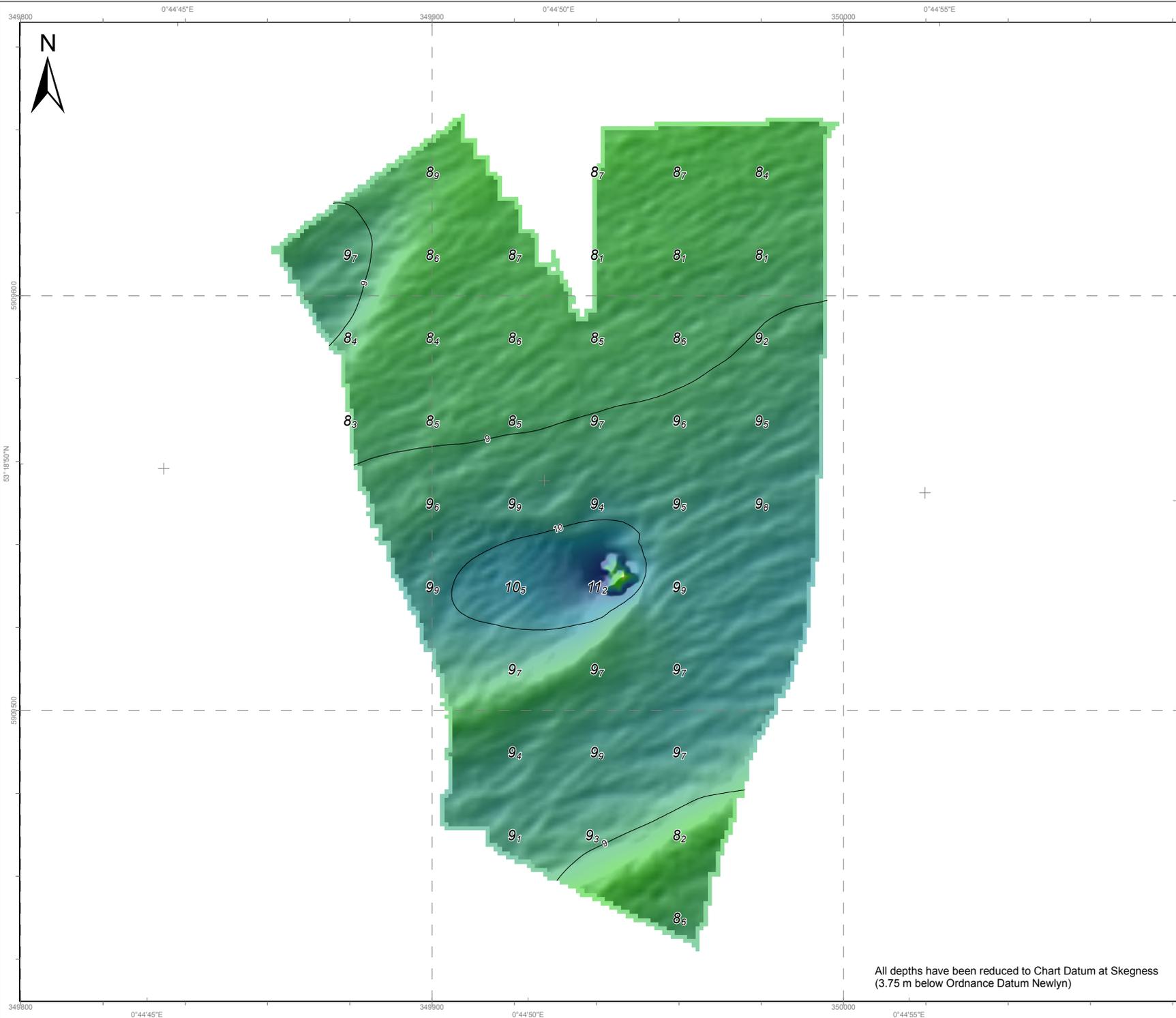
**Project Title**  
Lynn and Inner Dowsing  
Hydrographic Monitoring Survey

**Figure Title**  
Colour Shaded Bathymetry  
around Docking Shoal Metmast

**J.1.02.1495.02c**

|                         |                               |                                   |                  |
|-------------------------|-------------------------------|-----------------------------------|------------------|
| <b>Drawn By:</b><br>IMR | <b>Issued On:</b><br>14/12/09 | <b>Job Number:</b><br>J/1/02/1495 | <b>Rev:</b><br>1 |
|-------------------------|-------------------------------|-----------------------------------|------------------|

All depths have been reduced to Chart Datum at Skegness  
(3.75 m below Ordnance Datum Newlyn)



**Coordinate System**  
WGS84 UTM Zone 31 North

**Survey Contractor**  
Emu Limited  
Ph: +44 (0) 1489 860050  
Fax: +44 (0) 1489 860051  
website: www.emulimited.com  
email: mail@emulimited.com

**Client**

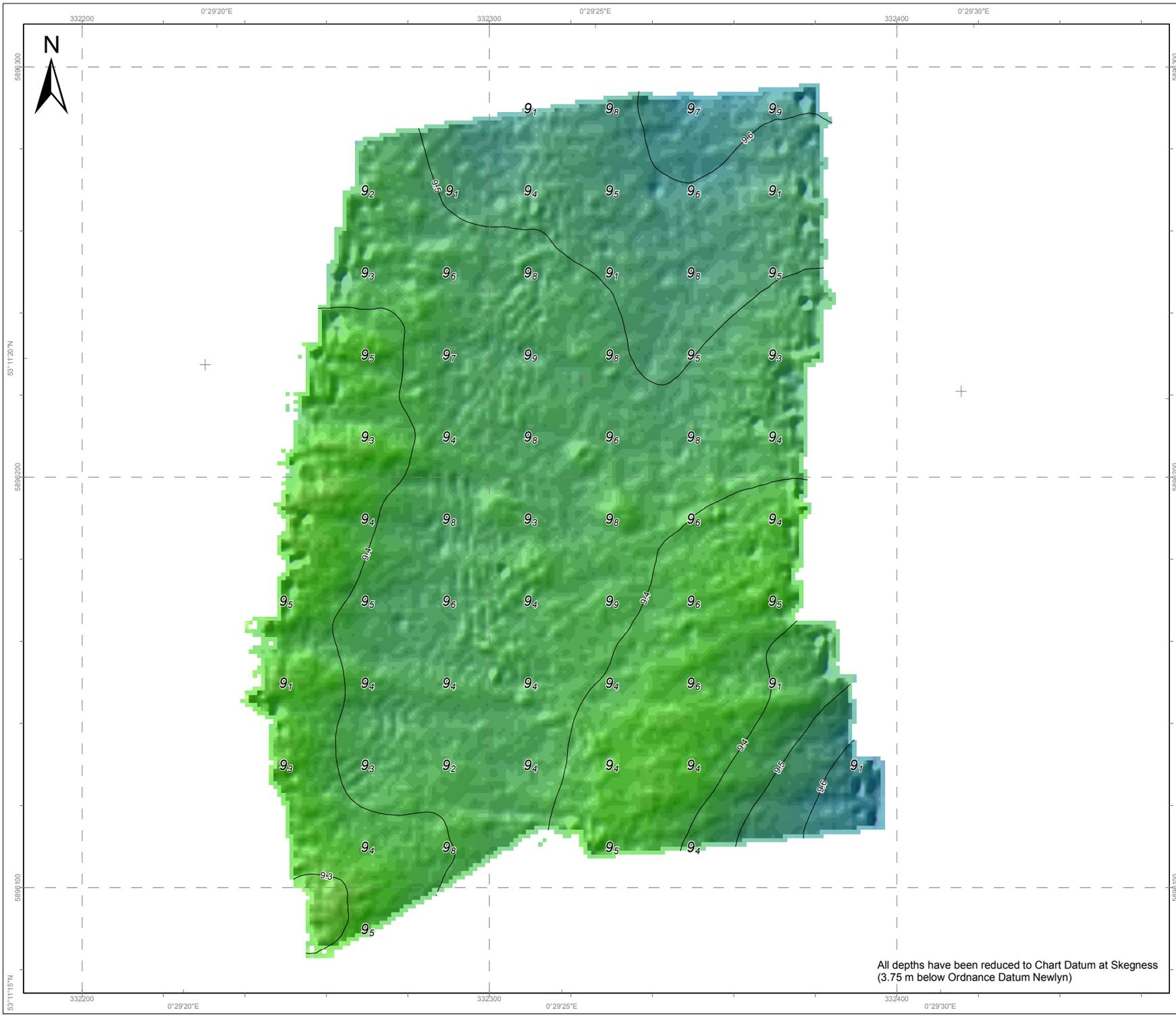
**Project Title**  
**Lynn and Inner Dowsing  
Hydrographic Monitoring Survey**

**Figure Title**  
Colour Shaded Bathymetry around  
Race Bank Metmast

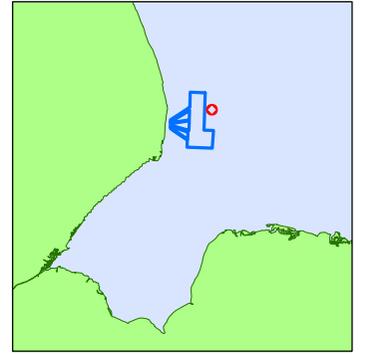
**J.1.02.1495.02d**

|                         |                               |                                   |                  |
|-------------------------|-------------------------------|-----------------------------------|------------------|
| <b>Drawn By:</b><br>IMR | <b>Issued On:</b><br>14/12/09 | <b>Job Number:</b><br>J/1/02/1495 | <b>Rev:</b><br>1 |
|-------------------------|-------------------------------|-----------------------------------|------------------|

All depths have been reduced to Chart Datum at Skegness  
(3.75 m below Ordnance Datum Newlyn)



**Location Map**

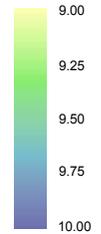


**Legend**

10<sub>5</sub> Depth Sounding (m)

— Contours

**Bathymetry (m below CD)**



**Scale**



**Coordinate System**

WGS84 UTM Zone 31 North

**Survey Contractor**

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 Fax: +44 (0) 1489 860051  
 website: www.emulimited.com  
 email: mail@emulimited.com



**EMU**

**Client**

**centrica  
energy**

**Project Title**

**Lynn and Inner Dowsing  
Hydrographic Monitoring Survey**

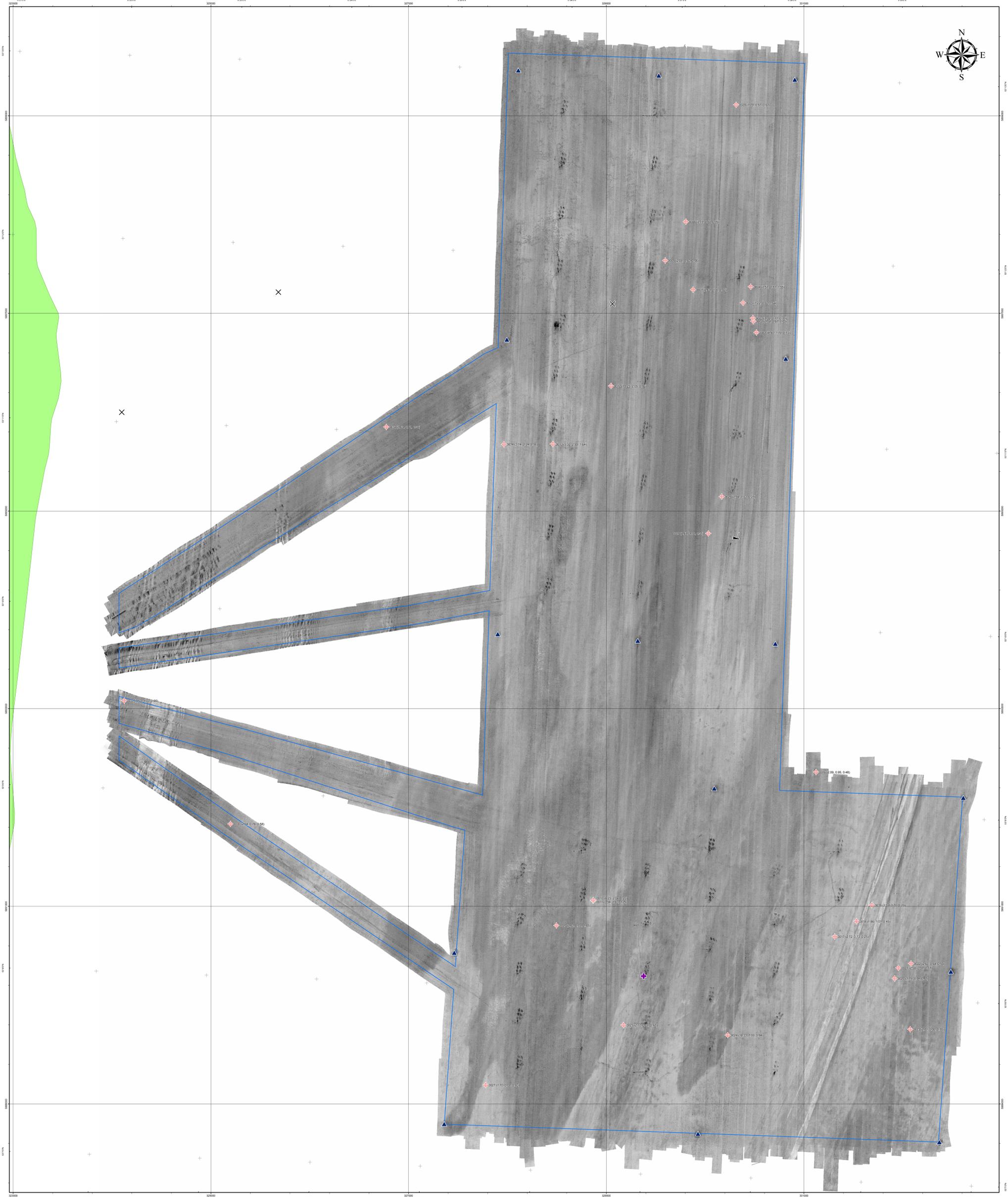
**Figure Title**

**Colour Shaded Bathymetry around  
the Proposed Substation**

**J.1.02.1495.02e**

|                         |                               |                                   |                  |
|-------------------------|-------------------------------|-----------------------------------|------------------|
| <b>Drawn By:</b><br>IMR | <b>Issued On:</b><br>14/12/09 | <b>Job Number:</b><br>J/1/02/1495 | <b>Rev:</b><br>1 |
|-------------------------|-------------------------------|-----------------------------------|------------------|

All depths have been reduced to Chart Datum at Skegness  
(3.75 m below Ordnance Datum Newlyn)



**Legend**

- Survey Area
- Hydrographic Features
- Lighthouse
- Mast (Approx. 2 m diameter)
- Charted Obstructions (No evidence based on survey data collected)
- Obstruction
- Wreck
- Contacts (Length, Width, Height) in metres

**Notes**

Coordinate System: WGS84 UTM Zone 31 North  
 Vertical Datum: All depths have been reduced to Chart Datum at Skagness (3.75 m below Ordnance Datum Newlyn)  
 Depths: All depths are in metres below Chart Datum  
 Vessel: FPV Moven  
 Date Surveyed: 30th June to 26th July 2009  
 Surveyors: JHC / SLD / DCS / ACH / AGR  
 Charted Obstructions: Captured from admiralty chart 108, edition date 30/10/2008

| Rev. | Date     | Description | Initials |
|------|----------|-------------|----------|
| 0    | 23/10/09 | Draft Issue | IMR      |
| 1    | 14/12/09 | Final Issue | IMR      |

**Equipment**

Positioning System: Primary - Applanix POS MV with differential corrections from Hemisphere Crescent R120 dGPS  
 Secondary - Hemisphere Crescent R120 dGPS  
 Navigation Data Acquisition System: GPS QINSY version 6  
 Motion Reference Unit: Applanix Pos MV  
 Vertical Heights: Leica 1200 PPK GPS  
 Multibeam Echosounder: Reson Seabat 8101 240kHz head  
 Multibeam Processing Software: GPS QINSY version 6  
 Sidescan Sonar System: Klein 3000  
 Sidescan Acquisition System: SonarPro  
 Sidescan Processing Software: SonarWiz version 4  
 Sound Velocity Probe: Valeport miniVP  
 FPV Moven Vessel Offset Diagram:

**Survey Location**

**Scale**

**Client**

**centrica energy**

Centrica Renewable Energy Limited  
 Millstream East  
 Mainstream Road  
 Windsor  
 SL4 5SD

**Survey Contractor**

**EMU**

Emu Limited  
 1 Mill Court  
 The Sawmills  
 Dursley  
 Southamption  
 Hampshire SO32 2EJ  
 Tel: +44 (0)1489 860050  
 Fax: +44 (0)1489 860051  
 E-mail: mail@emulimited.com  
 Website: www.emulimited.com

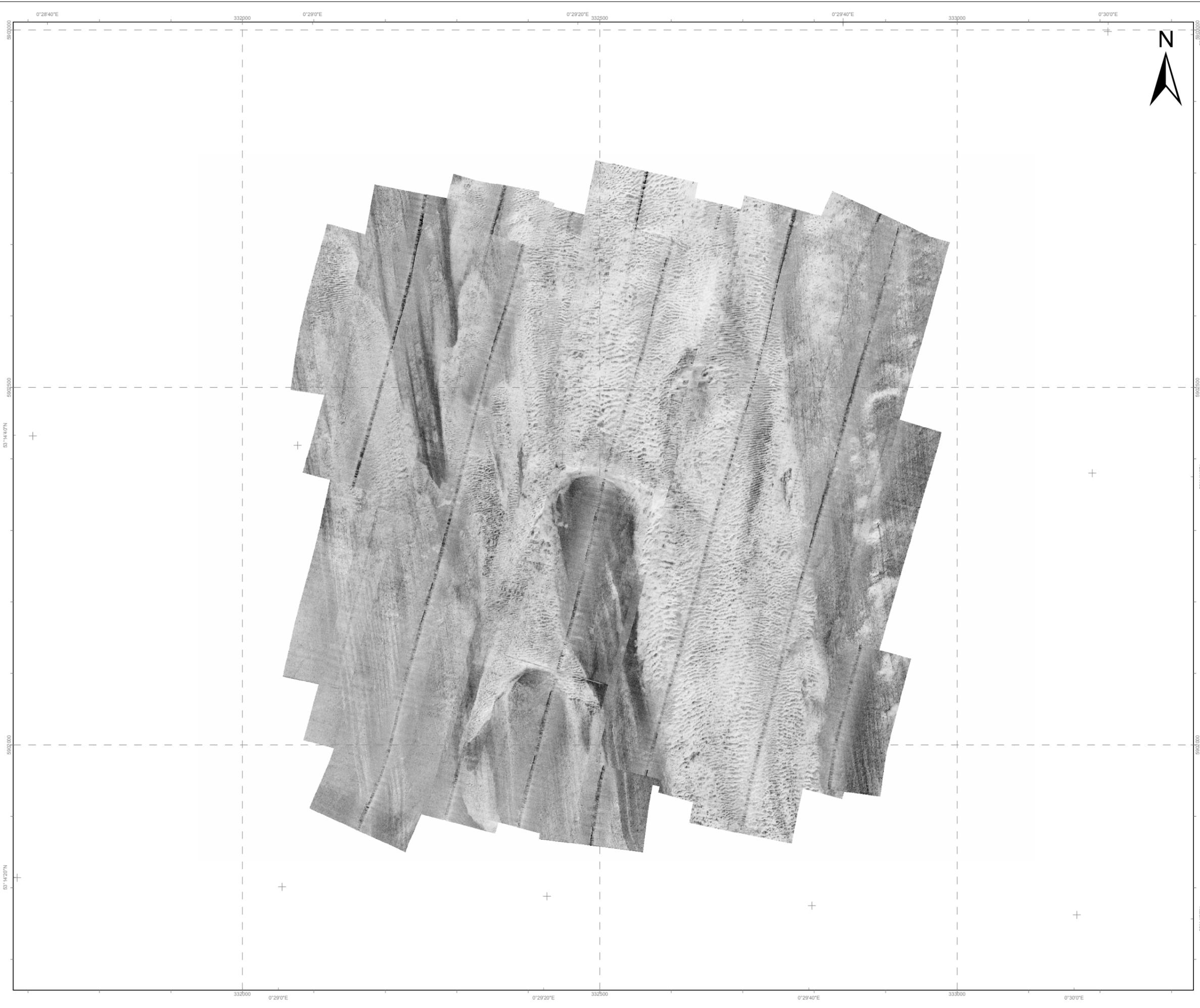
**Project Title**

**Lynn and Inner Dowsing Hydrographic Monitoring Survey**

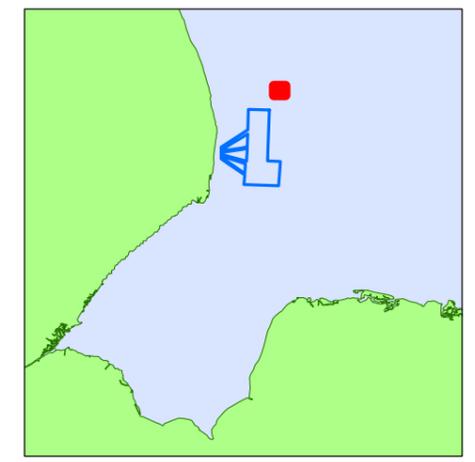
**Drawing Title**

**Sidescan Sonar Mosaic**

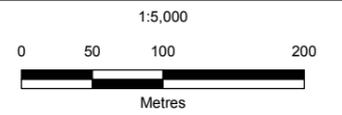
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| Job No.     | J/1/02/1495     | Date Issued | 14/12/2009 |
| Drawn by    | IMR             | Sheet Size  | ISO A0     |
| Approved by |                 | Scale       | 1:12500    |
| Drawing No. | J.1.02.1495.03a | Rev.        | 1          |



**Location Map**



**Scale**



**Coordinate System**

WGS84 UTM Zone 31 North

**Survey Contractor**

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 Fax: +44 (0) 1489 860051  
 website: www.emulimited.com  
 email: mail@emulimited.com



**Client**



**Project Title**

**Lynn and Inner Dowsing  
 Hydrographic Monitoring Survey**

**Figure Title**

**Sidescan Sonar Mosaic  
 of the Sandwave Area**

**J.1.02.1495.03b**

|                         |                               |                                   |                  |
|-------------------------|-------------------------------|-----------------------------------|------------------|
| <b>Drawn By:</b><br>IMR | <b>Issued On:</b><br>14/12/09 | <b>Job Number:</b><br>J/1/02/1495 | <b>Rev:</b><br>1 |
|-------------------------|-------------------------------|-----------------------------------|------------------|